Editorial

The Editorial Board is immensely delighted to bring out this Bulletin (Volume 28) of the Nepal Geological Society. This volume, like the previous ones, aims at updating the readers on the regular activities of the Society, and it also contains scientific articles on various topics of interest, abstracts of the papers presented in ISDR Day- 2010 and other Scientific Talk Programme which, we believe, to be of great to the readers.

Our sincere thanks are due to all the authors who have contributed their valuable papers to this volume. Similarly, we would like to thank all the members of the Society for their cooperation. The Editorial Board, on behalf of the Nepal Geological Society, gratefully acknowledges the financial and technical supports from the consulting firms, agencies and organizations.

We hope that the readers will find this volume to be useful and informative. Comments and suggestions for the further improvement of the Bulletin are highly welcomed.

Thank you ! **– Editors**

NEPAL GEOLOGICAL SOCIETY

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September 2009 – August 2011

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LIST OF PUBLISHED JOURNAL OF NEPAL GEOLOGICAL SOCIETY

1. Journal of Nepal Geological Society, Vol. 42 (in press)
2. Journal of Nepal Geological Society (Abstracts of Sixth Nepal Geological Congress on Geology, Geology, Natural Resources, Infrastructures, Climate Change and Natural Disasters, 15-17 November 2010), Vol. 41 (Special Issue), November 2010
3. Journal of Nepal Geological Society, Vol. 40, June 2010
4. Journal of Nepal Geological Society, Vol. 39, June 2009
5. Journal of Nepal Geological Society, Vol. 38 (Special Issue), December 2008
6. Journal of Nepal Geological Society, Vol. 37, June 2008
7. Journal of Nepal Geological Society (Abstracts of Fifth Nepal Geological Congress on Geology, Environment, and Natural Hazards Mitigation: Key to National Development, 26–27 November 2007), Vol. 36 (Special Issue), Novmember 2007
8. Journal of Nepal Geological Society, Vol. 35, June 2007
9. Journal of Nepal Geological Society (Proceedings of Fifth Asian Regional Conference on Engineering Geology for Major Infrastructure Development and Natural Hazards Mitigation, 28–30 September 2005), Vol. 34 (Special Issue),
10. Journal of Nepal Geological Society, Vol. 33, June 2006
11. Journal of Nepal Geological Society (Abstracts of Fifth Asian Regional Conference on Engineering Geology for Major Infrastructure Development and Natural Hazards Mitigation, 28–30 September 2005), Vol. 32 (Special Issue), September 2005
12. Journal of Nepal Geological Society, Vol. 31, June 2005
13. Journal of Nepal Geological Society (Proceedings of Fourth Nepal Geological Congress, 9–11 April 2004), Vol. 30 (Special Issue), December 2004
14. Journal of Nepal Geological Society, Vol. 29, June 2004
15. Journal of Nepal Geological Society, Vol. 28, June 2003
16. Journal of Nepal Geological Society (Proceedings of Third Nepal Geological Congress, 26–28 September 2001, Kathmandu, Nepal), Vol. 27 (Special Issue), September 2002
17. Journal of Nepal Geological Society, Vol. 26, June 2002
18. Journal of Nepal Geological Society (Proceedings of Workshop on the Himalayan Uplift and Palaeoclimatic Changes in Central Nepal, 10 November 2000), Vol. 25 (Special Issue), December 2001
19. Journal of Nepal Geological Society (Abstract Volume of Third Nepal Geological Congress, 26–28 September 2001), Vol. 24 (Special Issue), September 2001,
20. Journal of Nepal Geological Society, Vol. 23, June 2001
21. Journal of Nepal Geological Society (Proceedings of International Symposium on Engineering Geology, Hydrogeology, and Natural Disaster with Emphasis on Asia, 28–30 September 1999, Kathmandu, Nepal), Vol. 22 (Special Issue), December 2000,
22. Journal of Nepal Geological Society, Vol. 21, June 2000
23. Journal of Nepal Geological Society (Abstract Volume of International Symposium on Engineering Geology, Hydrogeology, and Natural Disaster with Emphasis on Asia, 28–30 September 1999, Kathmandu, Nepal), Vol. 20 (Special Issue), 1999
24. Journal of Nepal Geological Society, Vol. 19, 1999
25. Journal of Nepal Geological Society (Proceedings of Second Nepal Geological Congress, 1995), Vol. 18 (Special Issue), 1998
26. Journal of Nepal Geological Society, Vol. 17, 1997
27. Journal of Nepal Geological Society, (Abstract Volume of Second Nepal Geological Congress), Vol. 16 (Special Issue), 1997
28. Journal of Nepal Geological Society, Vol. 15, 1997
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31. Journal of Nepal Geological Society (Abstract Volume of First Nepal Geological Congress, 1995), Vol. 12 (Special Issue), 1995
32. Journal of Nepal Geological Society (Proceedings of 9th Himalaya–Karakoram–Tibet Workshop, 1994), Vol. 11 (Special Issue), 1995
33. Journal of Nepal Geological Society, Vol. 10, 1995
34. Journal of Nepal Geological Society (Abstracts of 9th Himalaya– Karakoram–Tibet Workshop, 1994), Vol. 10 (Special Issue), 1994 29
35. Journal of Nepal Geological Society, Vol. 9, 1993
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37. Journal of Nepal Geological Society, Vol. 7, 1991
38. Journal of Nepal Geological Society, Vol. 7 (Special Issue), 1991
39. Journal of Nepal Geological Society, Vol. 6, 1989
40. Journal of Nepal Geological Society, Vol. 5, No. 1, 198835.
41. Journal of Nepal Geological Society, Vol. 4 No. 1 & 2, 1987
42. Journal of Nepal Geological Society, Vol. 4 (Special Issue), 1984*
43. Journal of Nepal Geological Society, Vol. 3, No 1 & 2, 1985
44. Journal of Nepal Geological Society, Vol. 2 No. 2, 1985
45. Journal of Nepal Geological Society, Vol. 2 (Special Issue), 1982*
46. Journal of Nepal Geological Society, Vol. 2, No. 1, 1981
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48. Journal of Nepal Geological Society, Vol. 1, No. 1, 1981*

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CONTENTS

NGS News

The 32nd Annual General Body Meeting (AGM) was held at the Auditorium Hall of the Department of Mines and Geology, Lainchaur, Kathmandu on Bhadra 31, 2067 (September 16, 2010). The meeting was chaired by Mr. J. N. Shrestha, the President of 14th Executive Committee of the Society and was conducted by Dr. Dinesh Pathak, General Secretary of the Society. Mr. J. N. Shrestha, the President, expressed his heartiest welcome to the Society Members in the 32nd AGM of the Society. Dr. Dinesh Pathak, the General Secretary, presented the Annual Report to the General Body highlighting the various activities and events which happened during the tenure of the 14th Executive Committee. He mentioned the main activities carried out by the society in the last year. They were : formation of different sub-committees, celebration of ISDR Day, strengthening the communication with NGS members, solving the problem of email/website of the Society, communication with G/O and I/NGOs, scientific talk programs organized by Scientific Sub-Committee, exchange of journal between other professional societies, preparation of Sixth Nepal Geological Congress, nomination of Honorary Members of the Society, NGS publication, organization of ISDR Day: 2010, organization of NGC-VI, organization of HKT workshop in 2012, publication of "Himalaya-Tibet Collision" Book, creating job opportunity and collaboration with NGO and I/NGO. Then, Mr. D. K. Napit, the Treasurer, presented the Financial Report, including the Auditor's Report, for the Fiscal year 2066/067 B. S. Following the presentation of the General Secretary and the Treasurer, a lively discussion session was held on various issues to address the questions of NGS members in connection with the Annual and financial reports. After long discussion both the reports presented by the General Secretary and Treasurer were approved by the AGM.

Prof. Dr. V. Dangol, Coordinator, Scientific Sub-Committee reported the activity of the committee during the last one year. Mr. P. S. Tater, Coordinator, Public Relation and Finance Sub-Committee explained the activities that were carried out by the committee. Dr. R. K. Dahal, the Coordinator, Communication and Information Sub-Committee, made a brief reporting on the activities of his sub-committee. Prof. Dr. B. N. Upreti, the Coordinator, Honorary Member Nomination Committee made a brief report on the selection of the Honorary Members Prof. Dr. K. Arita, Japan and Mr. J. M. Tater, Nepal in recognition of their contribution towards scientific research and development in the Himalayas. The progress on the preparation for the Sixth Nepal Geological Congress (NGC-VI) was reported by Mr. K. P. Kaphle, the Convener of the Congress. On behalf of the 14th Executive Committee, Mr. S. B. KC, Vice-President, expressed thanks to the NGS members participating in the 32nd AGM of the Society.

Nepal Geological Society, in association of Mitra Kunj and Russian Centre for Science and Culture supported by Kathmandu Metropolitan City (KMC) and Lalitpur Sub-Metropolitan City (LSMC), observed the **International Strategy for Disaster Risk Reduction (ISDR) - Day 2010** with a half day workshop on the UN theme "Making Cities Resilient : My City is Getting Ready" on October 27 Wednesday, 2010, at the Russian Centre for Science and Culture. The inaugural session of the workshop was chaired by Mr. J. N. Shrestha, the President, NGS, and the workshop was inaugurated and addressed by Mr. Ananda Raj Pokharel, the Secretary, Government of Nepal/Chief Executive Officer, Kathmandu Metropolitan City. The program was also addressed by Mr. Arjun Kumar Thapa, the Chief Executive Officer, Lalitpur Sub-Metropolitan City. With short background on the Disaster Day, Dr. Dinesh Pathak, the Program Coordinator and General Secretary of NGS, conducted the session. Dr. Jaya Kumar Gurung, the Convener of the NGS-ISDR Committee, delivered welcome speech on behalf of the organizing committee. Mr. Bishnu Bahadur Singh, the Chairman, Mitra Kunj thanked NGS for continued collaboration on the ISDR Day celebration. Mr. S. P. Mahato, the Director General, Department of Mines and Geology said that the workshop will be meaningful if the recommendations be implemented. On behalf of the ISDR Day organizing committee, Mr. S. R. Sharma presented the vote of thanks. There were four thematic presentations, each followed by discussion over the queries of participants. The workshop was divided into two sessions namely Inauguration Session and Technical Session. 124 participants were present on this program.

Sixth Nepal Geological Congress-2010 on "Geology, Natural Resources, Infrastructures, Climate Change and Natural Disasters" was organized by the Nepal Geological Society on 15 - 17 November, 2010 in Hotel Everest, New Baneshor, Kathmandu, Nepal. The Chief Guest, Rt. Honorable President of Nepal, Dr. Ram Baran Yadav, inaugurated the 6th Nepal Geological Congress on 15 November, 2010. Three days long congress was attended by over 90 foreign participants from 22 countries and 150 Nepalese geoscientists. All together **5 Key note papers**, **6 Special papers**, **78 General papers** and **24 Posters** were presented by distinguished participants in three parallel, 15 Technical Sessions. Mr. K. P. Kaphle, the Convener of 6th NGC, summed up the over all program of 6th NGC and extended thanks to the participants. Mr. J. N. Shrestha, the President of NGS, extended sincere gratitude to the Rt. Hon. President of Nepal for his inauguration of the congress and his enthusiastic inaugural speech.

The International Workshop on 26th Himalaya-Karakoram-Tibet (HKT) was held in Canmore, Canada, in June 2011 and decided to organize the 2012 HKT in Kathmandu, Nepal. The 14th Executive Committee of the Society has decided the date of 27th Himalaya-Karakoram-Tibet (HKT) Workshop on November 29-30, 2012. The Executive Committee of the Society has nominated Dr. Dibya Ratna Kansakar as the Convener of the 27th Himalaya-Karakoram-Tibet (HKT) Workshop.

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32ND ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY
नेपाल भौगर्भिक समाजको बत्तीसैं साधारण सभा

Speech by Mr. Jagadish N. Shrestha, President of Nepal Geological Society

31st Bhadra 2067 (16th September 2010)

Auditorium Hall, Department of Mines and Geology, Lainchaur, Kathmandu

Respected Honorable Members of Nepal Geological Society,
Respected Members,
Ladies and gentlemen

It gives me great pleasure to welcome you all to the 32nd Annual General Body Meeting of our society. I thank you all for coming to this meeting in spite of your valuable and busy time schedule and at relatively short notice.

It has been exciting and eventful 30 years since the establishment of this society. What a great these 30 years have been!! During these 30 years our society has grown up to a healthy, alive and active body of more than 600 members from mere 42 founder members. It made an illustrious long and active history of working for professional well being of the Nepalese geoscientists and spreading geo-scientific knowledge through scientific publication, seminars, workshops, etc. Contribution of this Society to the advancement of knowledge in the Himalayan Geology cannot be under estimated. Indeed our society is probably the only one with such continuous history of achievements within our country.

It has been a year since you, the members of society, have given the responsibility of guiding the society to my fellow members of 14th executive committee and myself. As your president, I had tried to guide society towards new path and reactivate some of its old relations while continuing all activities. We have constituted the editorial board and several sub-committees to carry out various activities of the society. It is you to judge, to what extent we have been successful. Shortcomings are my own as I was out of activities of the society for the last 6-7 years because of my commitment to the service of the Government of Nepal and it took me some time again to reintroduce myself. You will hear the detailed report of what we have done during the past year from the report of our Secretary General, Dr. Dinesh Pathak.

One of major thrusts of action during the last year was to establish relation with various similarly oriented organizations. We have contacted several organizations and renewed contacts. These organizations have committed to help actively in our future endeavors.

Our major efforts were dedicated to lay ground preparations for the successful organization of the forth coming Sixth Nepal Geological Congress 2010. We have constituted the organizational committee with Mr. Krishna P. Kaphle, one of the past presidents of the society as the convener as well as several sub-committees required for covering the various aspects of the event under the leadership of experienced members of the society. I am happy to report you; we are making great progress in laying ground work of the congress organization. However, much works have still to be done and I request all members of the society to be active in various activities and help the subcommittees in fulfilling their responsibilities. In this regard, I would like to thank members of the society, Mr. Bharat Janwali and Mr. Som Sapkota, for their efforts in gathering financial support. We still need to work hard on financial front. You will hear details of all activities so far from Mr. Krishna P. Kaphle, the convener and Secretary General, Dr. Pathak.

We have submitted a proposal-request to the Government of Nepal through the Department of Mines and Geology, to provide a piece of land for construction of building of the society. The government has assured us to look positively into the matter.

I would like to inform you that the coming year will be quite busy in the life of our society. In October we are going to celebrate ISDR day as usual. After that it will come the landmark event of the Sixth Nepal Geological Congress during 15-17th November 2010. We will also continue the publication of the Journal and the Bulletin of the Nepal Geological Society and organization of series of lectures and seminars. We will also continue expanding our elation with other organizations.

Dear members, I have great pleasure in informing you that the 26th Himalayan- Karakorom-Tibet (HKT) workshop has agreed in principle to hold the 27th HKT workshop in Nepal in 2012. The international geo-scientific community

has once again shown its belief in the capacity of Nepal Geological Society and entrusted the organization of the workshop to us. The Nepalese geoscientists will have an opportunity to exchange views and learn from the experiences of eminent geo-scientists working in different aspects of the geology of HKT region. I am confident; with the combined efforts of all members we will fulfill our obligation as usual. I would like to mention here efforts of Prof. Dr. Bishal N. Upreti and Mr. Som Sapkota in this regard.

I take this opportunity to thank various organizations and persons for their financial, logistics and moral support such as various ministries of the government of Nepal, Department of Mines and Geology, CAIRN Energy PLC, Dr. Avouac of CALTECH USA, Dr. Bollinger of DASE, France, the Embassy of India, UNDP, ICIMOD and many others. Let me also thank all members of the society for their continued support and also chairmen, coordinators and members of various committees for their tireless efforts in society's work.

Dear friends, I regret to inform you I cannot be with you during this evening fully however much I would like to be because of the recent operation I had undergone. Regretfully I leave you with my friend Mr. Shyam Bahadur KC, the Vice President of the Society and other members of the executive committee. I ask the members, friends to come forward with constructive criticism and give suggestions for better performance of the society. I once again reiterate that whatever laggings are there in the activities of the society those are the laggings of my leadership and I alone bear responsibility for that.

Once again I heartily welcome you all to this 32nd Annual General Body Meeting!!
Thank you.

32ND ANNUAL GENERAL BODY MEETING OF THE NEPAL GEOLOGICAL SOCIETY

Annual Report by Dr. Dinesh Pathak, General Secretary, Nepal Geological Society

31st Bhadra 2067 (16th September 2010)

Auditorium Hall, Department of Mines and Geology, Lainchaur, Kathmandu

Respected Chairman

Respected Honorary Members of the Society
Respected Past Presidents
Distinguished Fellow Members
Ladies and Gentlemen

It is a great pleasure for me to welcome you all on behalf of the 14th Executive Committee of the Nepal Geological Society in the 32nd AGM of the Society. It is nearly one year since we took the responsibility of the office of the NGS. In the last one year, we have put our efforts to conduct different activities for the optimum achievement of the objectives of the Society. I will briefly present the work that we carried out during the last year and our future plan.

WORKS CARRIED OUT

Celebration of ISDR Day

• ISDR Day was observed and the report was circulated to members as well as other government and non-government organizations.

-Theme: Hospitals Safe from Disasters: Reduce Risk, Protect Health Facilities, Save Lives

- Around 100 participants were present

- 4 papers were presented

- Chief Guest: Dr. Govind Kusum, Secretary, Ministry of Home

• We received positive response from many organizations including UNDP, Oxfam, Action Aid Nepal.

• Dr. Jaya Kumar Gurung and the ISDR Celebration Team contributed for the successful organization of the event.

Strengthen the Communication with NGS members

• Building database of email addresses of NGS Members with respect to their membership number and status: database was updated through personal communication, internet search, with the help of other members

• Categorize the NGS members with respect to their organization and nationality: e.g. different government and semi-government offices, foreigners

• Around 400 member's email address has been updated and NGS news have also been circulated to the I/NGOs, Non-Member Geologists, other professional organizations. The following is the summary:

NGS Members	Number	Non-Members	Number
Ex com	*13*	Geologist	**64**
DMG	*40*	INGO	**44**
			(SDC, UMN, UN OCHA, UNDP, UNESCO, UNICEF, USAID, PLAN International, OXFAM, Save the Children, DFAT, Practical Action), ICIMOD
DoI	*36*	Professional Societies	IAEG, Nepal GIS Society, Nepal Engineers Association, Society of Engineering Geologist-India, Geological Society of India, JUAAN etc.
DoR	*6*		
ICIMOD	*4*		
NEA	*30*		
NRN	*49*		
others	*102*		
TU	*31*		
Foreigners	*74*		
Total	**385**		
Nepalese	*70%*		
Foreigners	*42%*		

If you have not received mail from NGS till date, please let us inform (info@ngs.org.np) your email address so that your email ID could be updated.

Formation of different sub-committees

• In order to ensure the involvement of the members in NGS activities and get support to the executive committee, different sub-committees were formed with specific job descriptions.

Solving the problem of email/website of the Society

• The email address of society (ngs@wlink.com.np) was brought in function

• Access to website was made possible

• Change the server of Society's web site hosting due to problem in world link server

• Dr. Ranjan Kumar Dahal is supporting as the Coordinator of Communication and Information Sub-Committee

• More materials will be put in the site in near future. Dr. Dahal will present a brief report in the matter.

Information dissemination

• Each and every activities of the Society has been regularly disseminated to the NGS members through email

• Any queries were promptly responded

Communication with NGO and INGOs

• Concerned Government and international agencies were constantly communicated. A smooth relationship has been established/re-established with them, especially with the UNDP.

• Notably, SAARC Secretariat, UNDP, Ministry of Home, Ministry of Environment, Ministry of Industry and Ministry of Science and Technology are some of the organizations in which discussions were held in order to disseminate the information of NGS and probable collaboration/support in NGS activities.

Organization of Talk Program

• The Scientific sub-committee initiated the organization of two talk programs

• A good number of audience participated in the program

• Dr. Vishnu Dangol, Coordinator of the Scientific Sub-Committee presents a brief report.

Exchange of Journal between other professional Societies

• We are in communication with other professional societies. Recently the Indian Geological Society has agreed to exchange the journal between the two societies after a long gap.

Preparation of Sixth Nepal Geological Congress

• Once we took the responsibility of NGS Executive Committee, the Convener and Co-Conveners of the Congress as appointed by previous executive committee was given continuation.

• We are working in close coordination with the Convener of the Congress Mr. KP Kaphle providing him every necessary support.

• The Congress Venue has been finalized at Administrative Staff College Hall.

• We received good response on our call of abstracts through First Circular and the Second circular has already been distributed. The details will be provided by Mr. K.P. Kaphle, Convener of the Congress.

• As far as the financial matter is concerned, we are giving our full effort to raise fund for the Congress through different organizations. The following is the progress so far we have made:

- Cairn Energy provided US$10,000. The support of our member Mr. Bharat Jnawali is praiseworthy.

- Embassy of India has committed to provide NRs. 160,000.00, out of which 80,000.00 has been deposited in NGS bank account while the remaining will be made available after the Congress.

- DASE France has confirmed to provide Euro 4000.00 and sponsor the geologists of Seismological Centre to participate in the Congress. Likewise, CalTech has made commitment of US$ 5000.00. Mr. Som Nath Sapkota has played vital role in generating funds from these two organizations.

- We are in communication with ICIMOD for fund and UNDP for financial support and collaboration in the Congress.

- The national consultancies are being contacted for support.

- The NGS members from DMG are trying to get support from industrial sectors.

- Mr. P. S. Tater, Coordinator of Public Relation and Financial Sub-Committee will further elaborate in Financial aspects.

Nomination of Honorary Member of the Society

• In order to nominate the Honorary members of the Society a three member committee was formed comprising of Prof. Dr. B. N. Upreti (Coordinator), Mr. Bharat Jnawali (Member) and Mr. Shyam KC (Member). The committee has recommended two persons and the executive committee has endorsed the recommendation. We will shortly come in the matter during this meeting.

NGS Publication

• An Editorial Board was formed with the Chief Editorship of Dr. Santa Man Rai. The board has been working in the publication matter. It has brought the Bulletin Volume 27, which is at your hand.

• Volume 39 of the Journal is in press and Volume 40 is at final stage, which will be shortly sent to press.

FUTURE PROGRAM

Organization of NGC-VI

• Continue work towards the successful organization and the Sixth Nepal Geological Congress to be held in November 2010. We do expect to receive full support from our members.

Organization of HKT workshop in 2012

• We have made approach to organize the HKT Workshop after a long gap in 2012. We also sent a request letter during last HKT in USA and the response is positive till date.

• Prof. Dr. B.N. Upreti and Mr. S.N. Sapkota had participated in the workshop and advocated on behalf of the Society. We need to make approach in future also.

Restructuring the website of Nepal Geological Society

• Restructuring the website of Nepal Geological Society

• Uploading the abstracts of NGS journals

• Uploading Bulletins of Nepal Geological Society

• Create a page with articles on various aspects of Himalayan Geology from Honorary Members and Senior Members of Nepal Geological Society.

Publication of "Himalaya-Tibet Collision" Book

• Professor George Mascle approached to publish the Himalaya-Tibet Collision Book in French and English. Nepal Geological Society will be the co-publisher of French version to be published from France while French Geological Society will be co-publisher in English version to be published in Nepal.

• We are in constant communication with Professor Mascle in this matter. Professor Upreti also had talked with him in France.

Establishment of Mitra-Rai Fellowship

• Dr. Kamala Kanta Acharya and Mr. Niraj Regmi made approach to the Society for the establishment of Mitra Rai Fellowship. We have principally agreed on the matter after series of interaction.

• Once the proposed amount NRs. 120,000. is made available and deposited in the bank account of Society, we will manage the distribution of scholarship from the amount obtained as the interest.

Land and Building of the Society

• Managing the land and constructing building of the Society is the long awaited matter for us. We had worked in this matter and contacted the concerned government officials and have submitted our request.

• We are in constant touch with them. We will inform you the outcome.

Creating Job Opportunity

• In order to create more position in the government organization, we had made approach in some organizations like the Ministry of Environment, Ministry of Science and Technology, NAST.

Collaboration with G/O and I/NGO

• Since we have been able to be in connection with the NGO and INGO, we will be continuously working towards further collaborative activities with these organization.

Dear Members, the above mentioned activities of the present executive committee would have never been materialized without your support and constructive advice. We would like to thank you for your co-operation, support and advice in the past and expect the same also in future.

Thank you all.

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Annual Financial Report by Mr. Dinesh Napit, Treasurer, NGS presented during the 32nd Annual General Body Meeting

नेपाल भौगर्भिक समाजका कोषाध्यक्ष श्री दिनेश नापितद्वारा प्रस्तुत आर्थिक प्रतिवेदन

यस सभाका सभापति ज्यू,
आदरणीय समाजका पूर्व अध्यक्षज्यूहरु,
१४ औं कार्यकारिणी समितिका साथीहरु,
साथै उपस्थित हुनुभएका समाजका साथीहरु,

यस १४ औं कार्यकारिणी समितिले आ.व. २०६६/६७ को एक वर्षका कार्यकालमा गरेका आर्थिक क्रियाकलापको प्रतिवेदन प्रस्तुत गर्न गइरहेको छु । साथीहरु, अडिटरको रिपोर्ट तपाई समक्ष पुगीसकेको हुनाले यहाँहरु समक्ष संक्षिप्तमा विवरण पेश गर्न चाहन्छु ।

१. गत वर्ष २०६६ साल असार मसान्तसम्म हामीसँग बैक मौज्दात रु. २५,०३,०७०।६४
२. यस वर्ष २०६७ साल असार मसान्तसम्म हामीसँग बैक मोज्दात रु. २२,८९,५८६।-, पेश्की रु ५०००।- र नगद रु १२,१००।- गरि जम्मा मौज्दात रु. २३,०६,६८३।१३ रहेको छ ।

बैक मौज्दात अन्तर्गत

- कृषि विकास बैंक (मुद्दती) मा रु ५५,०००।-
- कृषि विकास बैक (बचत) मा रु १२,२५१।४८
- नविल बैक (डलर खाता) मा USD 23,797.32 = रु १७,८६,९४०।७६ (एक ज्ञ. रु ७५।-)
- नविल बैक (मुद्दती) मा रु २९,०००।-
- नविल बैक (कल/चल्ती) मा रु ३४०,६८१।३८
- नेपाल बैक लिमिटेड (बचत) मा रु ५५,६७२।८३
- नेपाल बैक लिमिटेड (चल्ती) मा रु ९,९४९।६८ रहेको छ ।

नगद मौज्दात बापत देखिएको रकम रु २,५००।- चेक पेमेन्टबाट डिपोजिट भैसकेको रु ५००।- को श्रावण महिनाको विल समेत समावेश भएको देखिएको हुँदा सो कुरा अडिटरलाई जानकारी गराउँदा अन्तिम क्षण भएको देखिएकोले यस चालु आ.व.मा मिलाउन सकिने भएको छ ।

३. आ.व. मा
जम्मा आम्दानी रु ३,०४,८३५।०७
जम्मा खर्च रु ५,०१,२१९।०७ रहेको छ ।
खर्च र आम्दानीको विस्तृत विवरण Income and Expenditure Account मा दिइएको छ ।

४. यसरी हेर्दा आ.व २०६६/६७ मा आम्दानी भन्दा खर्च बढी भएको देखिन्छ । जुन रु १,९६,३८४।५१ ले बढी छ । मूख्यत आम्दानी भन्दा खर्च बढी देखिनुमा USD को विनिमय दरमा कमि आउनाले रु ७०,०००।- कमि हुन गएको, आ.व.२०६५/६६ मा पेश्कीको रुपमा रहेको रु ५४,०००।- मध्ये रु ४९,०००।- फछ्यौट भइ खर्चको रुपमा देखिन जानु र यस कार्यकारिणीले कार्यभार सम्हाल्ने वित्तिकै पहिलो भुक्तानी दिन बाँकी रहेको Journal Vol 37 र 38 साथै Bulletin 26 को भुक्तानी रु १,७५,४३०।५० दिनु परेकोले भएको देखिन्छ ।

५. यस आ.व.मा भएको आम्दानीले माथिको सबै कुरालाई सन्तुलन गरिसकेको हुँदा यस चालु आ.व.मा समाजलाई आर्थिक दृष्टिले सन्तोषजनक रहने देखिन्छ ।

अन्तमा हाल प्रस्तुत आर्थिक विवरण सम्वन्धी कुनै प्रतिक्रिया र सुझाव भए सोको अपेक्षा गर्दछु ।

धन्यबाद ।

दिनेश नापित

KESHAV RAJ BHATTARAI
Certificate No.: "B" 1534
Registered Auditor Membership No. : 1967

Auditors' Report
To
Members of
Nepal Geological Society
Kathmandu - Nepal

We have Audited the accompanying Balance Sheet of, Nepal Geological Society ,Kathmandu - Nepal as on Ashad 32, 2067 corresponding to July 16, 2010, and the related statements of Income and expenditure account and Balance sheet for the Year ended. Our responsibilities are to express an opinion on these financial statements based on audit .We believe that my audit provide a reasonable basis a reasonable basis for my opinion.

1. We have obtained all information and explanation , which to the best of our knowledge and belief were considered necessary for the purpose of our audit .
2. The books of accounts have been maintained as required by law.
3. The Balance Sheet, Income and Expenditure Account are drawn properly up in accordance with records which are made available .

In our opinion, the financial statement give a true and fair view of the financial position of the organisation as of Ashad 32, 2067 and if the results of its operation for the year then ended in accordance with Nepal Accounting Standard or relevant practices.

Keshav Raj Bhattarai
Registered Auditor
Place: Kathmandu ,Nepal

NEPAL GEOLOGICAL SOCIETY

INCOME & EXPENDITURE ACCOUNT

For the year 32nd Ashar 2067

Expenditure	Amount	Income	Amount
Advertisement	23927.75	Life Members	129550.00
Audit Fee	5000.00	Journal	22450.00
Bank Charge	1662.92	Registration Fee	28600.00
Hospitality	94622.00	Other Income	550.00
Printing Expensenses	175430.50	Entrance Fee	600.00
Remuneration, Wages	23550.00	Contribution	93647.50
Office Expensenses	41628.00	Interested Received ($106.22)	7976.05
Miscelloneous Expenses	32128.00	Interested Received	21461.01
Stationary Expenses	33144.25	Excess of Expenditure over Income	196384.51
Different in $ Rate	70125.65		
Total	**501219.07**	**Total**	**501219.07**

Note- US $1= NRs. 75.09

Note- US $1= NRs. 75.09 23691.1 1778964.70

Note- US $1= NRs. 78.05 23691.1 1849090.36

-70125.66

Treasurer General Secretary President Auditor

KESHAV RAJ BHATTARAI C.A. CLASS. 'B' Cert. No. 1534 Registered Auditor

NEPAL GEOLOGICAL SOCIETY

RECEIPT & PAYMENT ACCOUNT

For the year 32nd Ashar 2067

Receipt	Amount	Payment	Amount
Bank Balanced B/D	2503070.64	Advanced	5000.00
Life Members	129550.00	Advertisement	23927.75
Journal	22450.00	Audit Fee	5000.00
Registration Fee	28600.00	Bank Charge	1662.92
Other Income	550.00	Hospitality	94622.00
Entrance Fee	600.00	Printing Expensenses	175430.50
Contribution	93647.50	Remuneration, Wages	23550.00
Interested Received ($106.22)	7976.05	Office Expensenses	41628.00
Interested Received	21461.01	Miscelloneous Expenses	32128.00
		Stationary Expenses	33144.25
		Argi. Dev. Bank (Fixed Account)	55000.00
		Argi. Dev. Bank (Saving Accoun	12251.48
		Nabil Bank ($23797.32)	1786940.76
		Nabil Bank (Fixed Account)	29000.00
		Nabil Bank (Call Account)	340681.38
		Nepal Bank (Current Account)	9949.68
		Nepal Bank (Saving Account)	55762.83
		Different in $ Rate	70125.65
		Cash in Hand	12100.00
Total	**2807905.20**	**Total**	**2807905.20**

Note- US $1= NRs. 75.09

Note- US $1= NRs. 75.09	23691.1	1778964.70
Note- US $1= NRs. 78.05	23691.1	1849090.36
		-70125.66

Treasurer

General Secretary

President

Auditor

KESHAB RAJ BHATTARAI
CLASS 'B'
Cert. No. 1534
Registered Auditor

NEPAL GEOLOGICAL SOCIETY

Balance Sheet

For the year 32nd Ashar 2067

Assets	Amount
Bank Account	
Argi. Dev. Bank (Fixed Account)	55000.00
Argi. Dev. Bank (Saving Account)	12251.48
Nabil Bank ($23797.32)	1786940.76
Nabil Bank (Fixed Account)	29000.00
Nabil Bank (Call Account)	340681.38
Nepal Bank (Current Account)	9949.68
Nepal Bank (Saving Account)	55762.83
Advanced	5000.00
Cash in Hand	12100.00
Total	**2306686.13**
Last Year Surplus	2503070.64
Excess of Expenditure over Income	-196384.51
Total	**2306686.13**

Note- US $1= NRs. 75.09

Treasurer | General Secretary | President | Auditor

KESHAV RAJ BHATTARAI
CLASS- 'B'
Cert. No. 1534
Registered Auditor

NEPAL GEOLOGICAL SOCIETY
TRIAL BALANCE

For the year 32nd Ashar 2067

Account Head	Amount	Account Head	Amount
Advanced	5000.00	Bank Balanced b/d	2503070.64
Advertisement	23927.75	Life Members	129550.00
Audit Fee	5000.00	Journal	22450.00
Bank Charge	1662.92	Registration Fee	28600.00
Hospitality	94622.00	Other Income	550.00
Printing Expensenses	175430.50	Entrance Fee	600.00
Remuneration, Wages	23550.00	Contribution	93647.50
Office Expensenses	41628.00	Interested Received ($106.22)	7976.05
Miscelloneous Expenses	32128.00	Interested Received	21461.01
Stationary Expenses	33144.25		
Argi. Dev. Bank (Fixed Account)	55000.00		
Argi. Dev. Bank (Saving Account)	12251.48		
Nabil Bank ($23797.32)	1786940.76		
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Nabil Bank (Call Account)	340681.38		
Nepal Bank (Current Account)	9949.68		
Nepal Bank (Saving Account)	55762.83		
Different in $ Rate	70125.65		
Cash in Hand	12100.00		
Total	**2807905.20**	**Total**	**2807905.20**

Note- US $1= NRs. 75.09	23691.1	1778964.70
Note- US $1= NRs. 78.05	23691.1	1849090.36
		-70125.66

Treasurer General Secretary President Auditor

KESHAV RAJ BHATTARAI * CLASS-'B' * Cert. No. 1534 * Registered Auditor *

32ND ANNUAL GENERAL BODY MEETING OF NEPAL GEOLOGICAL SOCIETY

AGM Report

Nepal Geological Society
PO Box 231, Kathmandu, Nepal
Email: info@ngs.org.np
Website: www.ngs.org.np

16 September 2010

BACKGROUND

The Annual General Body Meeting (AGM) of Nepal Geological Society was held on Bhadra 31, 2067 (Sept 16, 2010) at the Auditorium Hall of the Department of Mines and Geology, Lainchaur Kathmandu. The NGS members were notified about the date and venue of the AGM through notice published in the Gorkhapatra Daily as well as email message. A brief description of the activities carried out during the meeting has been presented in this report. The NGS 14th Executive Committee believes that this summary report will be a record for the members who participated in the AGM and also will provide information to the members who were unable to participate in the meeting.

AGENDA OF THE AGM

The main agenda of the AGM were:

1. Briefing of works so far carried out and plan for coming year
2. Selection of Honorary Members of NGS (2067)
3. Preparation of the Sixth Nepal Geological Congress
4. Financial reporting
5. Miscellaneous

THE PROGRAM OF THE AGM

The AGM was conducted from 16:30 to 18:30 covering the above mentioned agenda and other queries raised by the members. The following was the program of the AGM:

Time	*Activities*
04:30 – 04:40	Registration
04:40 – 04:45	Call for Executive Committee Members to Dais
04:45 – 04:50	Welcome Speech by Mr. J.N. Shrestha, President
04:50 – 05:00	Annual Report by Dr. D. Pathak, General Secretary
05:00 – 05:05	Financial Reporting by Mr. D. K. Napit, Treasurer
05:05 – 05:10	Report by Prof. Dr. V. Dangol, Coordinator, Scientific Sub-Committee
05:10 – 05:15	Report by Mr. P.S. Tater, Coordinator, Public Relation and Financial Sub- ommittee
05:15 – 05:20	Report by Dr. R.K. Dahal, Coordinator, Communication and Information Sub- mmittee
05:20 – 05:35	Report on NGC-VI progress by Mr. K. P. Kaphle, onvener NGC-VI
05:35 – 05:50	Briefing by Prof. Dr. B.N. Upreti, Coordinator of Honorary Member Nomination Committee
05:50 – 06:25	Miscellaneous; Discussion
06:25 – 06:30	Vote of Thanks and Closing by Mr. Shyam K.C., Vice-esident

Mr. J. N. Shrestha, President, delivering welcome speech

The activities of the program were carried out within the specified time.

Summary of the Meeting Activities

The meeting started at the time specified in the program. The formal program started after the 14th executive members took their seat in the dais. The program was chaired by Mr. J. N. Shrestha, President of the Society and conducted by Dr. Dinesh Pathak, General Secretary of the Society.

Welcome Speech by Mr. J. N. Shrestha, President

Mr. J. N. Shrestha, President expressed his heartiest welcome to the Society Members in the 32nd AGM of the Society. He praised the active role played by the Society Members for the successful role of NGS towards professional well being of the Nepalese geoscientists and spreading geo-scientific knowledge through scientific publication, seminars and workshops during last 30 years. Mr. Shrestha thanked the members for giving him the responsibility to head the Society and mentioned that the major initiation of the 14th executive committee was towards establishing relationship with various concerned organizations and renew the relationship with them.

The major efforts of the Committee were dedicated to lay ground preparation for the successful organization of the forthcoming Sixth Nepal Geological Congress. The preparation of the Congress is in progress through the active

role of Mr. K. P. Kaphle, Convener of the Congress and other sub-committees formed for the Congress organization. Mr. Shrestha requested the NGS members for their support as and when necessary for the successful organization of the event.

Mr. Shrestha informed that the present executive committee has initiated to organize 27th Himalaya-Karakorum-Tibet (HKT) Workshop in 2012 in Nepal. The preliminary homework and exercise has shown positive response of the international geo-scientific community showing its trust to NGS for its capacity to organize such an international event. Such event would provide the NGS members an opportunity to exchange views and learn from the experiences of eminent geoscientists working in different aspects of geology of the HKT region. He thanked Prof. Dr. B.N. Upreti and Mr. S. N. Sapkota for their key role in making approach on behalf of the NGS.

At the end of his speech, Mr. Shrestha requested the participating members to provide constructive criticism in the past activities of the 14th executive committee and suggestions for better performance of the Society in future.

Annual Report by Dr. D. Pathak, General Secretary

The annual report of the Society was presented by Dr. Dinesh Pathak, General Secretary. He mentioned that the executive committee put its maximum efforts to conduct different activities for the optimum achievement of the objectives of the Society. The main activities carried out in the last year were the following:

Formation of different sub-committees

In order to ensure the involvement of the members in NGS activities and get support to the executive committee, different sub-committees were formed with specific job descriptions.

Celebration of ISDR Day

ISDR Day 2009 with the theme of "Hospital Safe from Disasters: Reduce Risk, Protect Health Facilities, Save Lives" was observed with the organization of half day workshop in presence of over 100 participants in which four papers were presented. Dr. Govinda Kusum, Secretary of Home Ministry was the Chief Guest of the ceremony. A brief report of the event was prepared and circulated to members as well as other government and non-government organizations. Very positive response was received from many organizations. Dr. Jaya Kumar Gurung and the ISDR Celebration Team contributed for the successful organization of the event.

Strengthen the Communication with NGS members

In order to strengthen the communication with NGS members, database of email addresses of NGS Members was updated through various means and tools. Likewise, the email addresses of concerned organizations and individual was also updated. As a result, it has been possible to disseminate the information regarding NGS activities and other professional activities in abroad can be sent to around 70% Nepalese members and 42% Foreign Members of the Society. Likewise, communication has also been made to various concerned organizations working in Nepal, with other professional societies and geologists who are yet to be NGS member. Each and every activities of the Society has been regularly disseminated to the NGS members through email and any queries raised by the members and other organizations were promptly responded.

Dr. Pathak requested to send a request mail to the Society (info@ngs.org.np) if anyone has not been receiving mails from NGS so that their email address could be updated in order to ensure the delivery of mail from the Society.

Solving the problem of email/website of the Society

When the present executive committee took the office, the website of the society was not accessible and the mails sent to the email address of society used to be bounced back to the sender. This problem was promptly solved. However, it was realized for better performance, it is necessary to change the server. It was materialized and at present both email addresses of the Society is functioning properly. The website of the society is under restructuring process and Dr. R.K. Dahal is supporting in this matter as the Coordinator of Communication and information sub-committee.

For one more year, we will be using both the email addresses of the Society (i.e. info@ngs.org.np and ngs@wlink.com.np). We are going to abandon the email address ngs@wlink.com.np by next year and we will be using only the web email address (info@ngs.org.np) of the Society. In order to materialize it, the NGS members are requested to use info@ngs.org.np by now onward to communicate with NGS. It is believed that for the individuals and organizations, one year time will be sufficient to update the Society's email address.

Communication with G/O and I/NGOs

Concerned Government and international agencies were constantly communicated. A smooth relationship has been established/re-established with them, especially with the UNDP, SAARC Secretariat, Ministry of Home, Ministry of Environment, Ministry of Industry and Ministry of Science and Technology.

Organization of Talk Program

The NGS scientific sub-committee initiated the organization of two talk programs in which a good number of audience were present.

Exchange of Journal between other professional Societies

As an endeavor of NGS to be in close communication with other professional societies. The Indian Geological Society has agreed to exchange the journal between the two societies after a long gap. Similar approach has also been made to other societies.

Preparation of Sixth Nepal Geological Congress

The present executive committee is working in close coordination with the Convener of the Congress Mr. KP Kaphle providing him every necessary support. The Congress Venue has been finalized at Administrative Staff College Hall. We have received good response on our call of abstracts through First Circular and the Second circular has already been distributed. As far as the financial matter is concerned, we are giving our full effort to raise fund for the Congress through different organizations and the NGS members, especially Mr. B.M. Jnawaly, S.N. Sapkota have provided full support in this matter as far as possible. So far we have received/got commitment of more than US$ 22,000.00 and expect to generate additional fund necessary for the organization of the Congress. Notably, Cairn energy, DASE France, CalTech, USA, Embassy of India have already provided/made commitment of handsome financial support for the Congress. We are in communication with other national and international organizations for raising further fund.

Nomination of Honorary Member of the Society

In order to nominate the Honorary members of the Society a three member committee was formed comprising of Prof. Dr. B.N. Upreti (Coordinator), Mr. Bharat Jnawali (Member) and Mr. Shyam KC (Member). The committee has recommended two persons and the executive committee has endorsed the recommendation, which was unanimously approved by the 32nd AGM. The following persons are the nominated Honorary Member of NGS:

- Prof. Dr. Kazunori Arita, Hokkaido University, Japan
- Mr. J. M. Tater, Kathmandu, Nepal

NGS Publication

An Editorial Board was formed with the Chief Editorship of Dr. Santa Man Rai. The board has been working in the publication matter. It has brought the Bulletin Volume 27, Journal Volume 39 is in press and Volume 40 is at final stage, which will be shortly sent to press.

Mr. D. K. Napit, Treasurer, presenting the financial report

Future Program

Organization of ISDR Day, 2010: The ISDR Day will be observed on October 2010. The final date will be announced later. The ISDR Theme for 2010 is "Making Cities Resilient".

Organization of NGC-VI: Continue work towards the successful organization and the Sixth Nepal Geological Congress to be held in November 2010.

Organization of HKT workshop in 2012: Full effort will be given towards organization of the HKT Workshop after a long gap in 2012.

Publication of "Himalaya-Tibet Collision" Book

Professor George Mascle (NGS Life Member) approached to publish the Himalaya-Tibet Collision Book in French and English. Professor Upreti and Dr. S. M. Rai also had communicated with him in this matter at the earlier stage. The French version has already been published in France in which Nepal Geological Society is the co-publisher. The English version will be published in Nepal in which French Geological Society will be co-publisher. We are in constant communication with Professor Mascle in this matter.

Establishment of Mitra-Rai Fellowship

Dr. Kamala Kanta Acharya and Mr. Niraj Regmi made approach to the Society for the establishment of Mitra Rai Fellowship. We have principally agreed on the matter after series of interaction. Once the proposed amount NRs. 120,000 is made available and deposited in the bank account of Society, we will manage the distribution of scholarship from the amount obtained as the interest.

Land and Building of the Society

Managing the land and constructing building of the Society is the long awaited matter for us. We had worked in

Prof. Dr. V. Dangol, reporting the activity of scientific sub-committee

Prof. Dr. B. N. Upreti, reading the biography of Prof. Dr. K. Arita

Mr. P. S. Tater, reporting the activity of public relation and finance sub-committee

Mr. K. P. Kaphle, Convener, NGC-VI, reporting the progress on Congress organization

this matter and contacted the concerned government officials and have submitted our request. We are in constant touch with them. We will inform you the outcome.

Creating Job Opportunity

In order to create more position in the government organization, we had made approach in some organizations like the ministry of environment, ministry of science and technology, NAST.

Collaboration with G/O and I/NGO

Since we have been able to be in connection with the G/O and I/NGO, we will be continuously working towards further collaborative activities with these organization. However, the leading role of NGS in the Geoscience related field will not be compromised.

Dr. Pathak mentioned that the above mentioned activities of the present executive committee would have never been materialized without the support of NGS members and their constructive advice. He extended sincere thank to all members for their co-operation, support and advice in the past and expected the same also in future.

Financial Reporting by Mr. D. K. Napit, Treasurer

Mr. D. K. Napit, Treasurer, presented the financial status of the Society. The Audit Report for the FY 2066/067 was distributed to the participating members in the AGM. He made a brief report on the income and expenditure during the last year. The following is the brief of financial status of NGS:

· Bank balance till the end of Asadh 2066: NRs. 25,03,070.64

Mr. S. B. K C, Vice-President extending Vote of Thanks

- Bank balance till the end of Asadh 2067: NRs. 22,89,586.00
- Advance till the end of Asadh 2067: NRs. 5000.00
- Cash till the end of Asadh 2067: 12,100.00
- Total till the end of Asadh 2067: 23,06,683.13
- ***Total Income during FY 2066/67: 3,04,835.07***
- ***Total expenditure in FY 2066/67: 5,01,219.07***

It seems that there has been more expenditure (by 1,96,384.51) than income during FY 2066/067. The reasons are the following:

- Due to decrease in US$ exchange rate
- Payment of advance of FY 2065/66
- Payment of journal volume 37, 38 and Bulletin 26 Payment due of previous Executive committee)

Mr. Napit mentioned that the above financial scenario indicates that the Society will be in sound financial condition during present FY (2067/68) as the payment due of previous FY (2065/66) has been paid from the income of last FY (2066/67). The financial report of Mr. Napit was unanimously approved by the AGM. Likewise, the issue was raised whether to continue the US$ account in bank or think for alternatives. Finally, it was concluded that in long run, keeping this account is beneficial to NGS and hence the meeting concluded to continue the US$ account.

Brief Reporting by the Coordinators of Different Sub-Committees

Prof. Dr. V. Dangol, Coordinator, Scientific Sub-Committee reported the activity of the committee during the last one year. He mentioned that two scientific talk programs were held in which many members participated and interacted during the program.

Prof. Dangol also requested NGS members to help him to arrange more talk programs in future through presenting research findings and communicating with the other researchers.

Mr. P. S. Tater, Coordinator, Public Relation and Finance Sub-Committee explained the activities that were carried out by the committee. He focused on strengthening the relationship between possible local donors. Mr. Tater also expressed his approach to raise financial support to organize the NGC-VI. The members suggested him to seek support of NGS members to make approach to concerned organization. Mr. D. N. Subedi and Mr. R. Khanal suggested for making approach to some organization.

Mr. Tater expressed his commitment to actively engage in fund raising activities for making strong financial condition of NGS.

Dr. R. K. Dahal, Coordinator, Communication and Information Sub-Committee made a brief reporting on the activities of his sub-committee. He elaborated on the situation of communication system of the Society and threw light on future activities to be carried out. Dr. Dahal also reported on the issues related to the restructuring of the NGS website.

Reporting by Prof. Dr. B. N. Upreti, Coordinator, Honorary Member Nomination Committee

Prof. Dr. B. N. Upreti, Coordinator, Honorary Member Nomination Committee made a brief report on the selection of the Honorary Members Prof. Dr. K. Arita and Mr. J.M. Tater. Prof. Upreti read the biography of Prof. K. Arita and his contribution in the study of Nepalese Himalaya as well as to the Society. Likewise, Mr. B. M. Jnawali, Member of the Committee read the biography of Mr. J.M. Tater. The contribution of Mr. Tater in the establishment of Society and his role in the Geo-scientific activities in Nepal was explained by him. The recommendation of the committee was unanimously approved by the meeting.

Reporting by Mr. K. P. Kaphle, Convener, Sixth Nepal Geological Congress

The progress on the preparation for the Sixth Nepal Geological Congress (NGC-VI) was reported by Mr. K. P. Kaphle, Convener of the Congress. He explained the mode of communication adapted to disseminate the Congress information. Mr. Kaphle informed that more than 190 abstracts have been received for the Congress from more than 27 countries. He expects around 140 foreign

participants in the Congress. The selection of Congress venue was justified and requested for the support of all NGS members.

Vote of Thanks and Closing by Mr. S. B. KC, Vice President

On behalf of the 14th Executive Committee, Mr. S. B. KC, Vice-President expressed thanks to the NGS members participating in the 32nd AGM of the Society. Likewise, the support of Department of Mines and Geology through providing the Auditorium Hall for the meeting and all the individuals and organizations who directly and indirectly supported for the organization of the meeting was gratefully acknowledged.

Finally, Mr. KC announced the closing of the AGM.

CONCLUSION

The 32nd AGM of Nepal Geological Society was successfully completed. Fruitful discussions were made and constructive suggestions were obtained for the present executive committee. We do appreciate the interest shown by the NGS Members.

This report has been prepared as part of the information dissemination activity of Nepal Geological Society, which the 14th Executive Committee considers one of the important task to make the NGS member aware about the activities of NGS. Respecting the information right of NGS Members, we are continuously preparing and disseminating the report of main activities of NGS. We do always expect your constructive suggestion and guidelines for making the Society more dynamic, objective oriented, transparent and a successful professional organization.

This report incorporates the discussion notes provided by Mr. A. K. Duvadi and photographs taken by Mr. U. Raghubansi. Their contribution is gratefully acknowledged.

Contact

The NGS 14th Executive Committee would be pleased to receive your comments, suggestion, guidelines, and compliment. Please direct your say to:

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INTERNATIONAL DAY FOR DISASTER REDUCTION
ISDR DAY 2010
Making Cities Resilient: My City is Getting Ready

Workshop Report

Organized by:

Nepal Geological Society
in association with
Mitra Kunj and Russian Centre of Science and Culture
Supported by: Kathmandu Metropolitan City (KMC) and Lalitpur Sub-Metropolitan City (LSMC)
Kathmandu, Nepal
27 October 2010, Wednesday

ABOUT NEPAL GEOLOGICAL SOCIETY (NGS)

Nepal Geological Society is the professional umbrella of all geologists working in Nepal and has over 600 members among which more than 170 scientists are from foreign countries. The Society was established in 1980 with the aim of developing and promoting the research and application of geological sciences to the national development through fostering high professional standard among members; promoting and protecting the professional interests of earth scientist of the country and to play an active role in the protection and conservation of environment through reducing the natural disaster.

Since its establishment, the Society has been working towards the advancement of geosciences in Nepal and is playing a leading role towards building up consensus among the government and private sectors on the role of geosciences on the national development. The Society is organizing the international as well as national level seminar, workshop and frequent talk programs. The Journal of Nepal Geological Society is the only one scientific journal regularly published from Nepal that incorporates research findings focused to the Himalayan Regions. The bulletin of the Society incorporates the articles that are more focused to the interest of general public.

NGS and Disaster Risk Reduction activities

The geological disaster (landslide, flood, earthquake) are the major threat to the national development and poverty alleviation in Nepal. Therefore, Nepal Geological Society initiated the advocacy in the area that included awareness campaign through the regular celebration of the International Day for Disaster Reduction (UN/IDNDR) since 1990s, occasional publication of disaster-related booklets etc. Likewise, after the establishment of UN ISDR (United nation International Strategy for Disaster Reduction), the Society has carried its activities in line with the UN/ISDR aims of building disaster resilient communities by promoting increased awareness of the importance of disaster reduction for reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental disasters.

The activities of NGS towards Disaster Prevention was acknowledged by UN Humanitarian and Emergency Relief Co-ordination Office of IDNDR Secretariat in Geneva, by awarding UN-Sasakawa Disaster Prevention Award in 1998 for its efforts in disseminating the scientific knowledge and spreading the awareness of prevention of the natural disaster.

Nepal Geological Society is committed to continue to advocate for disaster risk reduction and mitigation activities in the country. This professional organization is always open to have partnership with other national and international organizations involved in this sector.

THE ISDR DAY 2010

Nepal Geological Society (NGS) is a professional organization that is committed to work towards reducing hazard, vulnerability, and resulting disaster in the country. It has been working in disaster inventory, preparedness and advocacy since its establishment (last three decades). United Nation (UN) proclaimed the theme to celebrate disaster day 2010-2011 as: *Making Cities Resilient - My City is Getting Ready*. Giving high priority to this theme NGS organized a half day workshop on October 27, 2010 in collaboration with Mitra Kunj and Russian Centre for Science and Culture. The program was supported by Kathmandu Metropolitan City and Lalitpur Sub-Metropolitan City.

The program was organized in the Russian Culture Center hall, Kamal Pokhari, Kathmandu. There was around 130 participation of researchers and policy makers; those working in the disaster sectors in different aspects. The program was inaugurated and addressed by Mr. Ananda Raj Pokharel, Secretary, Government of Nepal/Chief Executive Officer, Kathmandu Metropolitan City. The program was also addressed by Mr. Arjun Kumar Thapa, Chief Executive Officer, Lalitpur Sub-Metropolitan City. There were four thematic presentations, each followed by discussion over the queries of participants. The workshop was divided into two sessions namely Inauguration Session and Technical Session.

Guests sitting on the dais during Inaugural Session. Program conducted by Dr. D. Pathak, Program Coordinator.

INAUGURAL SESSION

With short background on the Disaster Day, **Dr. Dinesh Pathak**, Program Coordinator and General Secretary of

NGS conducted the session and the **Chief Guest – Mr. Ananda Raj Pokhatel**, Secretary, Government of Nepal, inaugurated the workshop.

Dr. Jaya Kumar Gurung, Convener of the NGS-ISDR Committee delivered welcome speech on behalf of the organizing committee. Dr Gurung welcomed all the guests, resource persons and participants in the workshop. In his welcome speech Dr. Gurung reiterated that Nepal Geological society has long been recognized for research initiatives, regular publication, organization of national/

Dr. J. K. Gurung, Convener of ISDR Day-2010 delivering the welcome speech.

international seminar workshop and has contributed in development and disaster mitigation endeavors.

Dr. Gurung mentioned that ISDR Day has been observed by NGS since long, specially focusing on interactive workshop and seminar with view to share the knowledge and practices of disaster management and to generate awareness among the stakeholders. In this connection, the theme given by the UN for this year: Making Cities Resilient: My City Getting Ready, is highly relevant in the context of rapid and haphazard urbanization.

He said that NGS has realized the municipalities as the main stakeholders responsible for the disaster management and has made series of fruitful consultation meeting with municipalities, especially Kathmandu Metropolitan City (KMC) and Lalitpur Sub-Metropolitan City (LSMC) for organizing this workshop. On behalf of the organizing committee, he thanked the KMC and LSMC for their supports through providing technical papers and financial contribution. In addition, he mentioned that the three invited papers from traffic management, solid waste management and ambulance management are equally important issues to be covered for the disaster management. He believed that at the end of the workshop NGS will be able to produce a report with assessment of our present capacity, identifying substantial activities to be done and practical recommendations to the Govt and policy makers.

Mr. Bishnu Bahadur Singh, Chairman, Mitra Kunj thanked NGS for continued collaboration on the ISDR Day celebration. He added that the mutual collaboration between the two organizations has helped to share the experiences of the graduates from Russia in earthquake disasters in Russia and the preparedness practices. Mr. Singh informed that Mitrakunj is also acting proactive support for any initiative of any organization in development endeavors. He stressed the need of an active forum in the South Asian Level for disaster mitigation activities.

Mr. Ananda Raj Pokharel, Secretary, Government of Nepal and Chief Executive Officer of Kathmandu Metropolitan City, and Chief Guest of the function said that this year's ISDR Day theme is highly relevant in Nepalese context and also in entire Asia Pacific region. Mr. Pokharel recalled the 1934 and 1988 earthquakes that hit Nepal.

Mr. Pokharel informed that KMC has made an attempt to incorporate the elements necessary for the construction of earthquake resistant buildings. However, the high-rise buildings and other large infrastructures might be vulnerable to earthquake.

Mr. Pokharel said that the open spaces are shrinking every other day and the Kathmandu Metropolitan City has made some arrangements for storing rescue materials in

Mr. Ananda Raj Pokharel, Secretary, Government of Nepal and Chief Executive Officer, Kathmandu Metropolitan City, addressing on the

the open spaces. In addition, KMC has been organizing training to the local masonry technician (Rajmistri) each year. However, still there are lots of challenges. KMC have realized that there needs to the strong role of Structural Engineers to make building earthquake proof and therefore KMC is actively working to create the position of structural engineers in municipalities. Mr. Pokharel also added that the building code needs to be implemented by department of urban development and building construction.

KMC is organizing Disaster Drilling very often. A drill was successfully organized last year. He also talked about

Mr. Arjun Kumar Thapa, Chief Executive Officer, Lalitpur Sub-Metropolitan City, addressing on the function

Mr. J. N. Shrestha, President, Nepal Geological Society addressing on the inaugural session

Mr. S. P. Mahato, Director General, Department of Mines and Geology is delivering his speech in the function.

the other cross-cutting issues like, provision of vehicle for rescue operation, decreasing of forest coverage, solid waste is very critical in Kathmandu Valley etc. KMC is encouraging for tree planting to make the city green. He raised concern that the penalty system for polluters is not being implemented effectively and the limited resources have hampered the implementation of disaster mitigation measures already formulated. Likewise, the possible impact of climate change on the environment need to be considered by the KMC in future planning.

Mr. Pokharel expected strong suggestion and recommendation from this workshop to the policy makers and the implementers. He iterated the commitment of KMC to implement the disaster risk reduction activities involving all the stakeholders.

Mr. Arjun Kumar Thapa, Chief Executive Officer, Lalitpur Sub-Metropolitan City, thanked NGS for invitation in the workshop. He stressed that the issue and efforts being made by LSMC is very similar to that of KMC. Mr. Thapa suggested for discussions also in other issue such as flood disaster.

Mr. S. P. Mahato, Director General, Department of Mines and Geology, said that the workshop will be meaningful if the recommendations be implemented. He mentioned that DHM is working since last 30 yrs in the disaster related sector. He informed that DHM has contributed to resolve the issues in Kathmandu Valley by producing maps of engineering and environment geological aspects as well as seismic micro-zonation, which need to update.

On behalf of the ISDR Day organizing committee, **Mr. S. R. Sharma** presented the vote of thanks. He thanked the Chief Guest, other guests on the dais, all the participants, collaborative organizations and supporters for their support and participation in the ISDR Day organized by the Nepal Geological Society.

Mr. Jagadishwar Nath Shrestha, Chairman of the session and President of Nepal Geological Society thanked the participants for their presence in spite of their busy schedule. He stressed that Nepal is geologically situated in a zone that is vulnerable to natural disaster. Because of this reason, Nepal Geological Society has been celebrating IDNDR and ISDR Day in cooperation with the concerned government and non-government organization so as to disseminate the information about disaster to the general public. The program was initiated when landslide, flood and earthquakes used to consider as the consequences of the angry god (*Daibi Prakop* in Nepali). Such program was acknowledged by the international award - UN Sasakawa Award to the Society. The Society is still committed to its

Chairperson and rapporteurs of the Technical Session

Participants' on the Technical Session

objective towards disaster risk reduction and have been continuously involved in various related activities.

Mr. Shrestha warned that the more we build up infrastructures, the more we do expect natural disaster to increase. The rapid urban sprawling is the indicative of centralized development that has its own complications. Because of this reason, the theme of this year's is very relevant to the Nepalese context. Therefore, Nepal Geological Society has invited representatives from Kathmandu Metropolitan City, Lalitpur Metropolitan City and Traffic Police to share their experiences and planning to cope with various urban disasters. Such information is expected to reach the general public and other relevant organizations which will be helpful to further design the disaster mitigation activities in urban area. He also requested all participants to actively participate in the discussion.

President Mr. Shrestha gratefully acknowledged the partnership between Nepal Geological Society, Government

Mr. T. M. Singh Pradhan, KMC delivering the presentation

bodies, local governments as well as Mitra Kunj and Russian Center of Science and Culture.

With the permission of the Chairman of the session, Dr. Dinesh Pathak, Program Coordinator, declared closing of the inauguration session and announced for ten minutes break before the start of technical session.

TECHNICAL SESSION

The technical session was chaired by Mr. Gopal Singh Thapa, First Elected President of the Nepal Geological Society who served at the different institutions of the Government of Nepal as Senior Geologist and at management level for several decades in the past. The rapporteurs were Mr. Khila Nath Dahal (Department of Irrigation) and Mr. Rajendra Khanal (Department of Mines and Geology).

Five thematic papers were presented in the technical session, which is briefly summarized below:

Status of the Disaster Management Functionality and its Implementation for Kathmandu Metropolitan City by *Tribhuwan Man Singh Pradhan,* *Disaster Management and Citizens' Safety Section, Kathmandu Metropolitan City*

Mr. Tribhuvan Man Singh Pradhan, Kathmandu Metropolitan City presented the synopsis of disaster management system development and its execution in the Kathmandu Metropolitan City over last decade. Mr. Pradhan said that the Disaster Management Section (DMS) was

Mr. B. K. Pant, DSP, KMTPD, presenting the Traffic Management in Kathmandu Valley.

established in 1998 (2054/55 BS) under the Welfare Department of the Kathmandu Metropolitan City (KMC), which was later changed to Disaster Management and Citizen Safety System in 2006, which work under Urban Development Department.

The Geographical Information System (GIS) based database preparation was initiated in 1998/99 to assess disaster assessment in the first phase in three wards (ward nos. 5, 18 & 20) of the Metropolitan, which was applied to other wards in later phase. With some examples, Mr. Pradhan showed that the project included mainly four elements namely: identification of surface based earthquake vulnerable houses; fire prone area and epidemic prone area; awareness campaign and delineation of open area that is required as part of earthquake reduction and mitigation programs. In addition, the information was disseminated through Web site of KMC, Metro FM/Nepal Mandal and Hamro Kathmandu TV Program, Formation of disaster management committee in ward level, and Disaster Preparedness Training conduct and pre-preparedness of emergency rescue stores in different location of KMC territory.

Mr. Pradhan highlighted that KMC has been working with different partner organizations (national and international) towards disaster risk reduction and mitigation program, especially in earthquake disaster. It has also been part of City 2 City funding program of Global Fund for Disaster Risk Reduction, funded by WB.

The Sub-Metropolitan city has raised the public awareness level on disaster, strengthened the coordination mechanism among different stakeholders and policy intervention has been started for urban expansion. Mr. Shrestha concluded that still there are lots of challenges like allocation of adequate open spaces and deficiency of the essential services (drinking water supply, waste disposal, health centers), in which his office is focused at present and expect to receive support from individual to the state.

Traffic Management in Cities of Kathmandu Valley: Present Status & Challenges *by Basanta Kumar Pant,* *Kathmandu Metropolitan Traffic Police Division*

Mr. B. K. Pant, KMTPD covered the traffic management issues in the Kathmandu Valley resulting from the traffic volume that is increasing day by day where as the expansion of road and other infrastructures have not been developed in the required level. It has caused tremendous pressure on the city roads. He briefly overviewed the developmental history of the Metropolitan Traffic Police Division, starting from Sadar Traffic Police Office in 1955 (2012 BS), to valley traffic police office in 1992 (2049 BS). Once the Metropolitan Police concept was introduced in the Kathmandu Valley in 2006 (2063 BS), it came to the present state.

Mr. Pant discussed the organizational structure that is enforcing the Vehicle and Transportation Management Act, 2049 BS (1992) and regulate smooth flow of traffic in Kathmandu Valley. The challenges and priorities of this Division constitute smooth and unhindered movement of traffic, reduction in accidents and casualties and create traffic awareness among road users and the community,

Prevention and reduction of road traffic accidents, effective enforcement of traffic rules and regulations, develop the sense of discipline amongst road users and educate the public including school children on road safety, ensure smooth and secure traffic movement for special occasions, VVIP and VIPs' movement, enhance the skill of traffic police, assist and advice various stakeholders in coordinated development of infrastructure for smooth and safe flow of traffic are the main objectives of traffic management. The vision set is: Safe and smooth flow of traffic in Kathmandu Valley. The mission set to achieve the vision is: effective and efficient traffic management and promotion of road traffic safety.

Traffic management during the disaster in the valley, especially during an earthquake, needs sound coordination of different stakeholders such as fire brigade, hospitals, drinking water etc. The major activities required for the disaster preparedness are precise information, identification of safe zone/affected areas and co-ordination with the related agencies.

Initiatives of Lalitpur Sub-Metropolitan City Office for Earthquake Disaster Risk Reduction by *Prabin Shrestha,* *Lalitpur Sub-Metropolitan City*

Mr. Prabin Shrestha, on behalf of the Lalitpur Sub-Metropolitan City, presented a paper on the initiation towards earthquake disaster risk reduction. He discussed about the implementation of National Building Code (NBC) in Building Permit Process and other DRR related activities of the City.

Mr. Shrestha highlighted that the main goal of the Sub-Metropolitan City Office is to develop the city as an earthquake safe city to live in. In this regards, he explained the various activities carried out since last eight years to meet this objective. Implementation of National Building Code was one of such important actions followed by demonstrative trainings, orientations and awareness programs with the support from various organizations.

Mr. Shrestha discussed the various initiatives undertaken by LSMC in the field of earthquake disaster risk reduction in the city area.

Solid Waste Management and Disaster *by Nahendra Pradhan,* *SASCON Pvt. Ltd.*

Mr. Nahendra Shrestha presented how an effective solid waste management activities can help to reduce disaster, especially health disaster. This is especially of prime concern of the metropolitan areas where large population resides and huge volumes of waste are produced creating challenges for its effective management. Though solid waste management is a never-ending problem in the urban area, it is necessary to make the people aware on value and impact of wastes. Mr. Shrestha discussed about the issues of Okharpauwa landfill site project. He concluded that there is need to work together with the local community surrounding the dumping site for smooth operation of the system.

Further, he added that the provision of management of solid waste generated during the disastrous event (e.g. earthquake) is vital to ensure the smooth functioning of life lines during the post disaster phase. Planning can help a community identify its debris collection, recycling, and disposal options. Although the recovery process will take a long time, perhaps even years, careful planning will prevent costly mistakes, speed recovery, and avoid creation of more waste.

Ambulance Service in Nepal by, *Mahesh Nakarmi*

Mr. Mahesh Nakarmi started his presentation through the existing ambulance services in Nepal. He showed some of the painstaking photographs in which the patients/injured persons are being inappropriately handled and the lack of minimum facilities in our ambulances. He mentioned that there is neither primary medical facilities available within the ambulance neither a medical staff is present.

Mr. Nakarmi informed that he is working towards providing a well equipped ambulance services within the Kathmandu valley that would help to save lives of the people who need immediate medical treatment. Likewise, he also highlighted on the need of proper management of medical wastes generated from the hospitals and nursing homes.

WRAP UP SESSION

After the presentations, an intensive discussion took place among the presenters and audience about the different aspects of the presentations and disaster and mitigation in general. Various queries from the audiences were answered by the presentations. After the discussions a list of general inferences and recommendations were drawn and passed by the workshop.

Session Chairman Mr. G.. S. Thapa wrapped up the session summarizing the essences of each four papers categorically. Mr. Thapa expressed that he himself learnt many things from the presentations and discussions about the disaster management initiatives taken by the municipalities are praiseworthy and expressed his concern towards effective implementation of the rules and regulations.

Mr. Thapa lauded the hard working of Valley Traffic Police in spite of insufficient manpower, lack of traffic lights/signals, bad road condition, insufficient road network, negligence of drivers and poor understanding and negligence of the situation by the concerned government authorities.

Finally, Mr Thapa concluded that the workshop is a success as it could extract the substantial outcomes over the announced theme “Resilient Cities” from the disaster point of view. Thanking to the organizing committee and the Nepal Geological Society, and all resource persons and participants, he ended the technical session.

With the permission of Chairman, Dr. Pathak, General Secretary of the Society, thanked all the experts, professionals and participants for their presence and announced the closing of the half day workshop.

General inferences and Recommendations

· Appropriate disaster management activities should be carried out. The rules and regulation required for effective implementation of disaster management activities should be strictly imposed.

· Such activities should foresee the future population and allocate adequate provision in view of urban sprawling.

· Government should improve the road condition and construct link roads, install traffic lights, educate people and punish to those disobeying the traffic rules. It is necessary for effective management of the traffic in urban areas like Kathmandu.

· The bridges, overhead bridges and narrow roads should be rehabilitated so that the roads can function in case of major disaster within the valley.

· A good coordination mechanism should be established for appropriate pre-disater , disaster and post-disaster management. It is necessary to ensure smooth functioning of these bodies as and when necessary.

OUTCOME

· National status & strategy concerning the disaster management in urban area, especially in the Kathmandu Metropolitan and Lalitpur Sub-Metropolitan Cities were known to experts, professionals and policy makers who participated in the workshop

· This workshop helped to strengthen better networking among the different actors functioning in the disaster management such as traffic police, urban planners, engineers, medical practitioner etc.

· Pragmatic recommendations related to urban disaster risk reduction to concern entities and individual working in the disaster management have come out from the discussion.

ACKNOWLEDGEMENT

Nepal Geological Society would like to express many thanks to Dr. J. K. Gurung, Convener and the members of ISDR Day organizing Committee for their active role in the organization of the workshop. The role of Kathmandu Metropolitan City and Lalitpur Sub-Metropolitan City in the organization of this half day workshop is praiseworthy.

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SIXTH NEPAL GEOLOGICAL CONGRESS 2010

Sixth Nepal Geological Congress on **"Geology, Natural Resources, Infrastructures, Climate Change and Natural Disasters"** was organized by the Nepal Geological Society on 15 - 17 November 2010 in Hotel Everest, New Baneshor, Kathmandu, Nepal. The Chief Guest, Rt. Honorable President of Nepal, Dr. Ram Baran Yadav inaugurated the 6th Nepal Geological Congress on 15 November 2010. Three days long Congress was attended by just over 90 foreign participants from 22 countries (Austria-3, Bangaladesh-6, Bhutan-2, Canada-1, France-10, Czech Republic-1, Georgia-1, Germany-2, India-17, Italy-4, Japan-13, S. Koria-1, Mexico-3, Norway-1, Pakistan-9, Poland-1, Russia-5, Singapore-1, Taiwan-1, Ukrine-1, USA-8) and about 125 participants from Nepal. 169 abstracts of the research papers are published in the Abstract Volume as Special Issue (volume 41) of the Journal of Nepal Geological Society. All together **5 Key note papers**, **6 Special papers**, **78 General papers** and **24 Posters** were presented by distinguished participants in three parallel, 15 Technical Sessions. All the technical sessions went very smoothly and timely with the help and cooperation of the Session Chairmen, Co-Chairmen, Rapporteurs and the paper presentators. Immediately after each presentation some time were allocated for discussions. All the discussions were held very lively atmosphere. The deliberations were quite interesting and informative, and most of the papers were up to the international standard. This congress has provided ample opportunities for all the participating Geoscientists to exchange their views, share experiences and knowledge among the professional groups. The objective of the congress is fulfilled with great cooperation and helps of the participants, organizing committee members, all sub-committee members who had worked hard day and night.

During Inaugural Ceremony Nepal Geological Society has awarded Honorary Fellow Membership of Nepal

Rt. Honorable President of Nepal, Dr. Ram Baran Yadav inaugurating the congress

Honorary fellow members with Rt. Honorable President of Nepal, Dr. Ram Baran Yadav

Prof. K. Arita receiving Honorary Fellow Membership by Rt. Honorable President of Nepal, Dr. Ram Baran Yadav

Prof. G. Fuchs receiving Honorary Fellow Membership by Rt. Honorable President of Nepal, Dr. Ram Baran Yadav

Mr. J. M. Tater receiving Honorary Fellow Membership by Rt. Honorable President of Nepal, Dr. Ram Baran Yadav

Geological Society to four distinguished geoscientists Prof. G. Fuchs (Austria), Prof. K. Arita (Japan), Prof. M. P. Sharma (Nepal) and Mr. J. M. Tater (Nepal) who had contributed significantly in the research and development of the Geology of Nepal Himalaya. The Chief Guest was very kind to distribute the Honorary Fellow Membership to them.

At the end, a short Valedictory Session was also organized to sum up the over all programs and also know the views of the participants on the Congress. In the beginning representative participants from India, Pakistan, France and Japan expressed their feelings about the congress and the hospitality. All of them were very satisfied from the congress program, food as well as the hospitality they got from NGS and Nepalese people on the whole. Mr. K. P. Kaphle, Convener of 6th NGC sum up the over all program of 6th NGC and extended thanks to the participants, Session Chairmen, Co-chairmen and Rapporteurs who could run the sessions smoothly and timely. He has also extended heartfelt thanks to various government and non-government organizations, Pvt. Companies and individuals who helped NGS by providing financial/ logistics supports. Mr. J. N. Shrestha, President of NGS extended sincere gratitude to the Rt. Hon. President of Nepal for inauguration of the congress and his enthusiastic inaugural speech. He has also expressed sincere thanks to all the participants and all the Organizing Committee Members, Executive Committee Members, and Sub-committee Members for their cooperation and helps to make the congress grand success. He had also extended his thanks to the Hotel Everest management and their staff for being kind enough to provide all necessary items as per the requirement and testy food. The 6th Nepal Geological Congress ended with grand success.

Both the Post Congress Field Excursions: EX-1 (Kathmandu - Butwal - Pokhara - Jomsom for 6 days) and EX-2 (Kathmandu - Kodari/ Tatopani for one day) were organized. Interested participants (14 participants in EX-1 and 21 participants in EX-2) took part in the excursions.

Nepal Geological Society is planning to publish the full papers presented in the congress in the special volume (vol. 43) of the Journal of Nepal Geological Society as Proceedings of the 6th Nepal Geological Congress by the end of November 2011. Therefore, all the participants who are interested to publish their papers in it, once again requested to submit their full papers before the end of December 2010.

(**Note**: This report was prepared by Mr. Krishna P. Kaphle, Convener, 6th Nepal Geological Congress, Nepal Geological Society, Nepal. - Editorial Board)

Distinguished participants attend the congress

Valedictory session of the congress

ABSTRACTS OF PAPERS PRESENTED IN WORKSHOP ON INTERNATIONAL DAY FOR DISASTER REDUCTION 2010 - MAKING CITIES RESILIENT: MY CITY IS GETTING READY

Status of the disaster management functionality and its implementation for Kathmandu Metropolitan City

Tribhuwan Man Singh Pradhan, Bimal Rijal, and Dhruba Kafle
Disaster Management and Citizens' Safety Section,
Kathmandu Metropolitan City, Kathmandu, Nepal

ABSTRACT

This paper gives the synopsis of disaster management system development and its execution in the Kathmandu Metropolitan City over last decade. Disaster Management Section (DMS) was established in 1998 (2054/55 BS) under the Welfare Department of the Kathmandu Metropolitan City (KMC). As its one main activity; DMS memorizes the historical earthquake of Nepal of 1934 (1990 BS, also called 90 Sal ko Bhuichalo) each year at Magh 2 at city center (Bhugol Park). Later at 2006 (2063) Disaster Management Section (DMS) changed to Disaster Management and Citizen Safety System which work under Urban Development Department.

A project based on Geographical Information System (GIS) both spatial and non-spatial data was launched in 1998/99 to assess disaster assessment in the first phase in three words of the Metropolitan (words no 5, 18 & 20) and later in other words. The project included mainly four elements namely: Identification of surface based earthquake vulnerability houses, Fire prone area and epidemic prone area in above mentioned wards, Awareness campaign, open area exhibition of about earthquake reduction and mitigation programs and information dissemination through Web site of KMC, Metro FM/Nepal Mandal and Hamro Kathmandu TV Program, Formation of disaster management committee in ward level, and Disaster Preparedness Training conduct and pre-preparedness of emergency rescue stores in different location of KMC territory.

In 2001/2002 KMC worked with different partner organizations (national and international). MoU was done with Earthquake Mega cities Initiatives (EMI) international organization for disaster risk reduction and mitigation program. Some efforts have been made for disaster assessment using the tools and techniques of Risk Assessment Tools for Diagnosis of Urban areas against Seismic Disaster (RADIUS) and HAZUS for disaster risk assessment analysis in every aspect (e.g., building construction, life line, socio-economic situation and day and night risk etc.). The Disaster Relief Fund has formed on 2007 for relief and rescue in disaster period.

The recent institutional development made (2008/2009) for the disaster management is the joint venture project being implemented along with some other organization (EMI, DKKV and NSET) in each wards of the metropolitan. Risk Sensitive Land use Planning Program in the salient feature of the projects. The elements of the projects are: formation of 7 members of disaster Working Committee, formation of Emergency Operation Plan, workshop, interaction and knowledge sharing program conducted at Kathmandu City and Makati City, Institutional exchange visit of the personnel between Makati City and Kathmandu City.

In 2066 (2009), Fire Brigade equipment and resource personnel has transferred from Ministry of Home Affairs (MoHA) and in 2009, MoU has signed between Makati, Quito and KMC for City 2 City sharing program of funding program of Global Fund for Disaster Risk Reduction, funded by WB.

As achievement public awareness level on disaster has been raised, coordination mechanism among different stakeholders has been strengthened and policy intervention has been started for urban expansion. Nevertheless, there are lots of challenges such as reducing the open spaces (safe place needed at disaster period) due high rate of urbanization, big deficiency of the essential services as drinking water supply, waste disposal, health centers. The situation naturally get worsen at disaster period. Special attention needs to pay in the disaster issue by all - from individual public to the state.

Traffic management in cities of Kathmandu Valley: Present status and challenges

Basanta Kumar Pant
Kathmandu Metropolitan Traffic Police Division,
Kathmandu, Nepal

The volume of the road traffic in Kathmandu valley is increasing day by day where as the expansion of road and other infrastructures have not been developed in the required level. The bourgeoning population and the increasing vehicular congestion have placed tremendous pressure on the city roads. The Metropolitan Traffic Police Division which was initially established as Sadar Traffic Police Office in 1995 (2012 BS), the same year Nepal police organization was formally established. Sadar Traffic Police Office renamed valley traffic police office in 1992 (2049 BS).

Came to this state in 2006 (2063 BS) after the Metropolitan Police concept was introduced in the Kathmandu Valley. The Division is headed by Additional Police Commissioner (DIPG) manned by 965 Traffic Police personnel. There are two Traffic Police Ranges, four Traffic Police Circles and Twenty two Traffic Police Sectors under its supervision. The division is responsible to enforce the Vehicle and Transportation Management Act, 2049 BS (1992) and regulate smooth flow of traffic in Kathmandu Valley. The challenges and priorities of this Division constitute smooth and unhindered movement of traffic, reduction in accidents and casualties and create traffic awareness among road users and the community.

The main objectives of traffic management includes : prevent and reduce road traffic accidents, Effective enforcement of traffic rules and regulations, develop the sense of discipline amongst road users and educate the public including school children on road safety, ensure smooth and secure traffic movement for special occasions, VVIP and VIPs' movement, enhance the skill of traffic police, assist and advice various stakeholders in coordinated development of infrastructure for smooth and safe flow of traffic. Other objective such as to ensure protection of the environment and take appropriate steps for prevention of environment pollution, to encourage participation and involvement of public in traffic management are also included.

The vision set is: Safe and smooth flow of traffic in Kathmandu Valley. The mission set to achieve the vision is: effective and efficient traffic management and promotion of road traffic safety.

According to UN definition lives and properties loss from accident also belong to the disaster. The rate of traffic disaster is increasing in major cities of Nepal especially of the Kathmandu Valley. It's true that loss of properties and lives could be reduced from the proper traffic management.

Besides, during some natural disasters such as earthquake traffic management is very important. Sound coordination of different stakeholders such as fire brigade, hospitals, drinking water is essential. The major activities included for the disaster preparedness includes: Precise information, Identification safe zone or affected areas, Creation of red zone, Co-ordination with the related agencies. (Fire Bridged, Ambulance, local police and army), Maximize capacity (Evacuation route), Traffic Diversion (Short term and long term), Service patrols (minimize unwanted traffic flow), Demarcation of red zone- Barrier, Diversion, F.M. AND Facilitate rescue operation, Route selection for Rescue vehicle (Ambulance, Fire bridged and security vehicle), Parking Management at the incidental area, Parking Management in the hospital. Planning plays an important role for any activities done during and after disaster.

Solid waste management and disaster

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Towns and cities around the world expand and population grows, volumes of waste produced increase and the challenges of solid waste management changes. Solid waste management has been a never-ending problem in the towns of Nepal, due to lack of knowledge on value and impact of wastes. A number of solid waste management projects have been studied. But none of them have been implemented except Okharpauwa landfill site project. Okharpauwa landfill site has been implemented but

it could not functioned due to local community problem and proper operational system. The concern is serious, particularly in the Kathmandu valley, which are often gateways to the business organization, diplomats, and tourists. Poor visual appearance of the city has been negative impacts on official and tourist visits and foreign investment.

Recognizing its importance, Government of Nepal had requested technical and financial support of GTZ and JAICA for improving solid waste management of Kathmandu valley. Projects was implemented and operated for few years. When project was handed over to the GoN, after that Project has been failed. This unsustainability of projects is due to various Political, administrative and Social constraints. At present, Solid waste has been managed in hit and miss way.

Every year natural disasters, such as fires, floods, earthquakes, hurricanes, and tornadoes, challenge communities of the world. These natural disasters have generated large amounts of debris, causing considerable disposal challenges for local public officials. Debris removal is a major component of every disaster recovery operation. Much of the debris generated from natural disasters is not hazardous. Soil, building material, and green waste, such as trees and shrubs, make up most of the volume of disaster debris. Most of this waste can be recycled into useful commodities.

Preparing a disaster debris management plan in advance can pay off in the event of a natural disaster. Planning can help a community identify its debris collection, recycling, and disposal options. Although the recovery process will take a long time, perhaps even years, careful planning will prevent costly mistakes, speed recovery, and avoid creation of more waste. A plan also can save money by identifying cost-effective debris management options and sources of help, increasing control over debris management in community, and improving administrative efficiency.

Three types of debris are associated with a disaster: Debris generated *directly* by the disaster, *indirectly* by the disaster and *abnormal patterns of life*.

Initiatives of Lalitpur Sub-Metropolitan City Office for earthquake disaster risk reduction

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Lalitpur Sub-Metropolitan City Office had announced the implementation of National Building Code (NBC) in Building Permit Process on the occasion of Earthquake Safety Day January 16, 2002. Lalitpur Sub Metropolitan City is the First Municipality in Nepal in the implementation of NBC in Building Permit Process. At the beginning Implementation of NBC was carried out by Technical Cell (Group of Municipal Engineers and Engineers from DUDBC, NSET, NESF and NEA) for 6 months. "Earthquake Safety Section" was established on 2003/11/27. Earthquake Safety Section is working together with "Building Permit Section" for implementation of NBC and other DRR related activities since its establishment.

The main goal of the Sub-Metropolitan City Office has been to develop the city as an earthquake safe city to live in. Hence, the office has been trying its best within the available resources, in this field and as an important step towards disaster management we have started several initiatives on earthquake risk mitigation, preparedness, response and recovery since last eight years. Our first most important step was the implementation of National Building Code. As Building Code implementation alone is not sufficient to achieve the goal, we have been conducting many forms of demonstrative trainings, orientations and awareness programs with the support from various organizations.

This paper on "Initiatives of Lalitpur Sub-Metropolitan City Office for Earthquake Disaster Risk Reduction" attempts to give a general overview of the initiatives undertaken by LSMC in the field of earthquake disaster risk reduction in the city area.

ABSTRACTS OF PAPERS PRESENTED IN THE SCIENTIFIC TALK PROGRAMMES

Development of a FORTRAN software for probabilistic seismic hazard assessment and its use in the seismic hazard analysis of Kathmandu Valley

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A FORTRAN software has been developed to calculate seismic hazard at a site. This program named 'NepHAZ-2011' can be used to calculate both Peak Ground Acceleration (PGA) and Spectral Accelerations (SA) both at a rock site and a soil site. This software utilizes the method of Cornell (1979) (explained in detail in Geotechnical Earthquake Engineering' by Kramer) to calculate seismic hazard at a site utilizing probabilistic approach. The input parameters to the software are the potential earthquake source characteristics, ground motion predictive relation, and seismic parameters specific to the identified potential earthquake sources. The software is expected to be useful in the hazard assessment of hydro power projects and other critical facilities in Nepal. The use of the software can be extended to anywhere in the world just after changing the ground motion predictive relation and input parameters specific to the region of interest.

NepHAZ-2011 has been used to calculate seismic hazard levels in the Kathmandu Valley. We have used ten aerial sources in current study, which have been identified after analyzing seismicity data. Target accelerations from 0.01 g (1 g = 9.8 m/s2) with an increment of 0.01g and up to 2.0 g have been considered to calculate their mean annual rate of exceedance. Such calculations have been done both for a hard rock site and a soft rock site. Peak Ground Acceleration corresponding to 10% chance of exceedance in 50 years (mean annual probability of 0.002) is called Design Ground Motion and most commonly is used in engineering designs of earthquake resistant structures and buildings. The Design Ground Motion is 0.53 g. The same predictive (Young's) relation has been used to calculate spectral accelerations in order to construct uniform hazard seismic response spectra at a rock site and a soil site. This work is expected to help policy makers and engineers to make the Kathmandu Valley safer from seismic hazards incorporating the findings in policy making and earthquake resistant design levels.

Surface rupture of 1934 Bihar Nepal earthquake: implications for seismic hazard in Nepal Himalaya

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Although the Main Himalayan Frontal Thrust (MHT/MFT), largest and fastest slipping continental megathrust, poses a major threat to the northern Indian sub continent, seismic hazard along it remains to be quantified. Based on historical descriptions of the two main 20th century earthquakes (1905, 1934), a consensus has emerged that neither produced surface ruptures, a view recently reinforced by paleo-seismological investigations in which only faulting much older than 1900 was found. This leaves us with fundamental, unanswered questions (recurrence times, rupture lengths, geomorphic signature of large events), and the ominous perspective of even greater quakes with displacements in excess of 15m, potentially on par with M H" 9 oceanic subduction events. Knowing the precise geometry and earthquake rupture histories of active faults is critical to assessing such hazard of the area.

To address such questions we have engaged into high-resolution geomorphic and paleoseismic studies of Main Frontal Thrust (MFT) in eastern Nepal. Long wavelength warping of river terraces show that late Pleistocene/Holocene deformation is well

expressed across frontal folds above the thrust, but the surface trace of the MFT, where sharpest, remains the best location to document whether large earthquakes break the ground and to determine their sizes and recurrence times. Our survey of the area between the Mahara Khola and Arun/Sun Khosi valleys show many promising outcrop of the young pristine scarps challenge the consensus of having no surface rupture of the recent 19th century earthquake. This area also belongs to the region entirely within the 1934 isoseismal VIII. In the valley of the Sir Khola, which crosses the northern branch of the MFT, we surveyed the rivercut refreshed the 26 m-high cumulative thrust scarp. Newly dated charcoal samples collected in the gravel layers of an uplifted strath terrace offset by thrusts nearly reaching the surface confirm the young age of the last event. Four distinct ^{14}C calibrated dates indicate that the terrace was emplaced less than 250 years ago, in the 18th or early 19th century, and was subsequently offset by F1, with a vertical throw of H" 1.5 m (H" 3 m of slip). This same terrace is offset again by another fault at the base of the main scarp. Since no other large earthquake than the Bihar-Nepal event was recorded locally in the 19th and 20th century, we conclude that the Sir Khola rivercut exposes the first surface trace ever found of the 1934 earthquake. We thus interpret this earthquake to be a repeat of the 1255 AD event that destroyed Kathmandu City (H" 700 yrs return time). Other charcoal ages in lower fluvial units of the footwall rapidly jump to 3000 years BP, and to older ages just below (up to 7000 yrs). This implies that stratigraphic section is missing, but also that there has not been much long-term incision by the river just south of the fault. Geophysical surveys including three shallow seismic profiles Electrical Resistivity Tomographic (ERT) sections ~1.5 km each, (Charnath, Sirkhola and Ratu Valley) and one Ground Penetrating Radar (GPR) profile at Thapatole near Bardibas which added invaluable information at various depths, complement the map view of the area. These 1.5 km long seismic profiles shot across the thrust in the Sir, Ratu and Charnath valleys image well the shallow part of the fault-plane down to H" 400 m depth. To our knowledge, at least in Nepal, this is the first effort of this kind to study the MFT at such a detailed scale in combination with paleo-seismological trenching.

Predictive landslide susceptibility mapping in the eastern Nepalese Himalaya

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The objective of the present study is to construct landslide susceptibility maps in a landslide prone area, Panchthar district, eastern Nepal, by means of bivariate and multivariate analyses using geographic information system (GIS) techniques as a basic analysis tool. GIS is used for the data management and manipulation. The DEM data are collected from the Survey Department of Government of Nepal, and aerial photo interpretation is used for the depiction of lineaments. The locations of landslides occurred in the study area are identified from field survey. Six pre-existing methods (frequency ratio, class variable analysis and area density methods as bivariate analysis; and logistic regression (LR), artificial neural networks (ANN) and decision tree (DT) as multivariate analysis) are utilized to produce the respective susceptibility maps. The three bivariate-derived methods are relatively simple and similar to each other in their applications, whereas the multivariate-derived methods are somewhat complicated in their utilization since each has to use different software for analysis.

A total of ten landslide-controlling factors (slope, aspect, curvature, distance from drainage, distance from lineament, stream power index, topographic wetness index, slope-length, geology and landuse) are implemented to produce final landslide susceptibility maps using individual methods, which are compared for their ability to predict landslide probability based on actual landslide events. The accuracies of the landslide susceptibility maps produced by individual methods are 81.9% for frequency ratio, 83.4% for class variable analysis, 79.0% for area density method, 81.6% for logistic regression, 78.3% for artificial neural networks, and 95.9% for decision tree method, indicating that the decision tree method is an incomparably better tool than the others. In fact the bivariate analysis method shows more relevant than the multivariate analysis method in this region.

ARTICLES

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Himalayan gemstones and their prospects in Nepal

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ABSTRACT

Nepal lies in the central part of the Great Himalayan Belt. The geological environment both in the Higher Himalayan as well as Lesser Himalayan regions is suitable for gemstones (precious and semiprecious stones) mineralization/ deposits. Gemstones are the important mineral resources that can be mined/ quarried economically in Nepal. So far very few private entrepreneurs are conducting gemstone exploration and also operating very small-scale traditional mines mainly of semiprecious stones like Tourmaline, Aquamarine/ Beryl, Garnet, Kyanite, Quartz crystal, and precious stones like Ruby and Sapphire, etc. by obtaining the prospecting and mining licenses from the Government of Nepal/ Department of Mines and Geology (DMG) since long time. But in many cases due to haphazard mining of gemstones without any technical knowhow has resulted considerable loss of the valuable resources and consequent environmental degradation in the area. Precious stones like Ruby and Sapphire are reported from the strongly tectonized lenses of saccharoidal dolomites within highly metamorphosed rock sequence close to the Main Central Thrust (MCT). Similarly semiprecious stones like Tourmaline, Beryl, Aquamarine, Garnet, and Quartz crystals are known from the complex pegmatites occurring mainly in the high grade metamorphic rocks (crystalline rocks). Deep red coloured Garnets and inky blue Kyanites are quite common in the Higher Himalayan crystalline zones. These gemstones are recorded and locally mined in different parts of Dhadhing, Rasuwa, Nuwakot, Manang, Dailekh, Jajarkot, Bajhang, Sankhuwasabha, Ilam, Panchthar and Taplejung districts. Some of the mines are already exhausted, and only few of them are in operation.

Keywords: Nepal Himalaya, gemstone exploration, prospecting and mining license, precious and semi precious stones, mines, production

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INTRODUCTION

Gemstones are the valuable natural resources which are present in different parts of Nepal Himalaya. Once beautiful coloured gemstones are cut and polished into attractive shape and size they get very good price in the international market and have bright future. The commercial value of precious stones varies as precious metals. In many cases the price of the gemstone depends also on the buyer's choice. Because of their high value, small volume and easy to transport they can be mined even in the remote areas without heavy equipments. According to the national policy of the Government of Nepal, Department of Mines and Geology (DMG) is giving priority to explore, evaluate and sustainable development of precious and semiprecious stones (Kaphle 2003) which are available in the country. Promotion of mechanized gemstone mines for better quality gems and their cutting, polishing facilities in the country and proper marketing of finished gemstones should get high priority. The value will be added tremendously (from 50 to >100 times) once the raw gems are properly cut into attractive shape, size and brightness by proper polishing. Considering the value and importance of gemstones in the country the gem cutting and polishing industries should get special privilege to establish the gem industries. Since infrastructure development works are going on in the remote virgin areas it is envisaged that within next few years time more gemstone deposits will be found and gem industries will be established which can contribute substantially in the economic development of the country. There is no Gemology course in the university level in Nepal. The Government of Nepal and the University Authority should think about its importance and include it in the university course and organize regular training courses on gemology, gem cutting, polishing and marketing etc.

OCCURRENCES AND THEIR QUALITY

Most of the gemstones are known mainly from the Higher Himalayan regions and very few of them from the Lesser Himalayan regions of Nepal. Almost all the known Himalayan precious stones like Ruby and Sapphire occur in strongly tectonized lenses of saccharoidal dolomite within the highly metamorphosed rocks lying immediately below the Main Central Thrust (MCT) or in the MCT zones. Similarly, Garnet prospects occur in strongly tectonized lenses of chlorite-biotite- garnet schist/ garnet mica schist that occur near to the MCT. Inky blue Kyanite is common

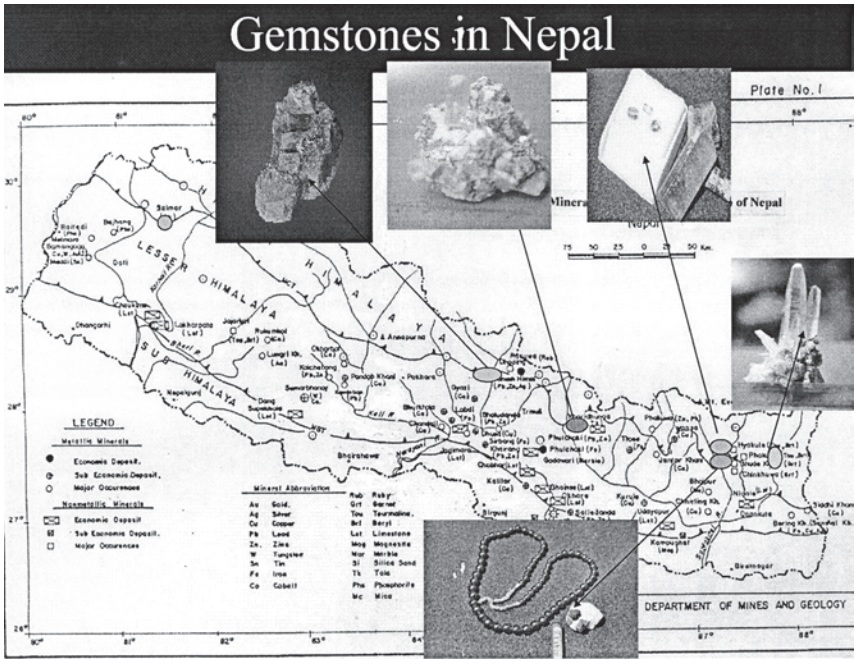


Fig. 1: Gemstone occurrences/ prospects/ deposits and mines in Nepal (Kaphle 2007)

in the kyanite/ sillimanite bearing schist in the Higher Himalayan Crystalline rocks as well as in few cases locally in kynite schist in the Lesser Himalaya. Whereas Tourmaline, Aquamarine/ Beryl, Quartz crystals, Feldspar, etc. occur in the complex zoned pegmatites, which have either discordant or concordant relation to the high-grade metamorphic country rocks in the vicinity of MCT (Fig.1) and in the crystalline Klippe. Basset (1984) did first geological study of Corundum in Ganesh Himal area. Bank et al. (1988) reported very fine gem quality Ruby in Nepal. Harding and Scarrett (1986) described about the Ruby occurrences in Nepal and Robinson et al. (1992) confirmed Ruby deposits in Chumar. Niedermayer et al. (1993) presented an overview on gems of Nepal and described Corundum deposits. Joshi (1985), Aryal (1988), Tamrakar (1990), Einfalt et al (1995) from DMG also conducted gemstone exploration in different parts of Sankhuwasabha, Taplejung, Jajarkot, Manang, Kathmandu, Dhading, Rasuwa and reported gemstone occurrences in their reports/ papers. During their field investigations they have noted that at many localities haphazard and illegal mining of gemstones by the untrained and unqualified local people (sometime using explosives) without any technical knowhow has resulted considerable loss of the valuable gemstones and consequent environmental degradation in the region.

GEMSTONES AND THEIR TYPES

On the basis of their specific physical characteristics, chemical and polishing properties and market value the gemstones are mainly divided into two types as (a) precious stones e.g. Diamond, Ruby, Sapphire, Topaz etc. and (b) semiprecious stones e.g. Tourmaline, Aquamarine/ Beryl, Zircon, Garnet, Kyanite, Amethyst, Citrine, Smoky quartz (quartz crystals), Spinel, Danburite, Amazonite, etc. Gemstones which are found in different parts of Nepal are briefly described below.

Precious stones

Among the precious stones only Ruby, Sapphire (Corundum), and Topaz are recorded in some specific locations in Nepal Himalaya. Diamond has not been yet recorded in Nepalese territory.

Rubies and Sapphire (Corundum)

Gem quality but generally small crystals of light red to red Ruby (Figs. 2, 2a, and 2b) and light to dark blue coloured Sapphire are known from Chumar and Ruyil villages in northern remote parts of Dhading district (UN/ESCAP, with DMG 1993) and few other localities in Shelghar, Shonglahas, Pola and Sublay in Rasuwa district. They occur in highly tectonized intensely folded en-echelon lenses of saccharoidal dolomite within the high-grade metamorphic rocks close to MCT (Smith et al. 1997, Basset 1987). Corundum (raw ruby) is also reported from Ilam (Tamrakar 1990) and Sapphire from Taplejung districts in eastern Nepal. Mining of these precious stones in Dhading is very difficult due to isolated locations in the far remote areas, high altitude, rugged topography, difficult terrain and harsh weather conditions. Because of crystal morphology, distinctive internal features and their colour-zoning, brightness and

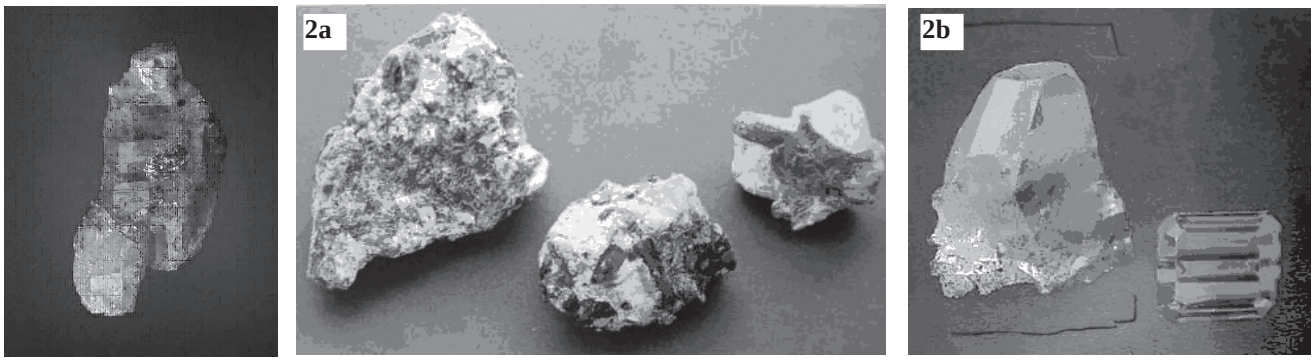


Fig. 2: Ruby from Chumar mine (Dhading), Fig. 2a: Raw Ruby, 2b: Ruby Crystal and cut and polished gem, (Photo source: Smith et al. 1997)

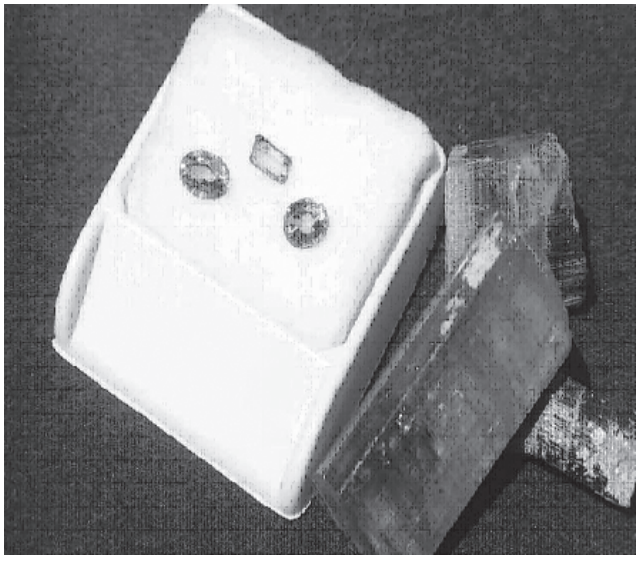


Fig. 3: Raw, cut and polished pink tourmaline from Hyakule (DMG 2000 and 2004)

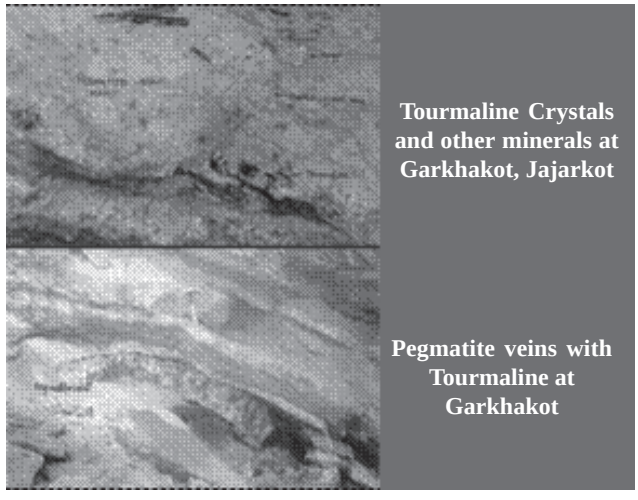


Fig. 4: Tourmaline crystals in pegmatite, Jajarkot (DMG 2000 and 2004)

wide variety of mineral inclusions rubies from this Himalayan region are very famous in the international market. A. M. Basset (1984) did first geological study of corundum in Ganesh Himal area, central Nepal. Later on Himalayan Gems, Nepal acquired the leases to Chumar and Ruyil areas and also did gem mining in 1985 (Basset 1985). Later on it has left mining activities due to difficult terrain and mining conditions. However, rudimentary illegal mining activities of such valuable minerals continued without any mining license and technical knowhow in Shelghar and Shonglahas areas and destroyed the valuable resources. Bassett has also reported two other potential areas for Corundum in Pola and Sublay. Therefore, through assessment and proper mining methods with technical advice is warranted to run the mine. At present no one has obtained the prospecting or mining license of Ruby and Sapphire from DMG..

Topaz

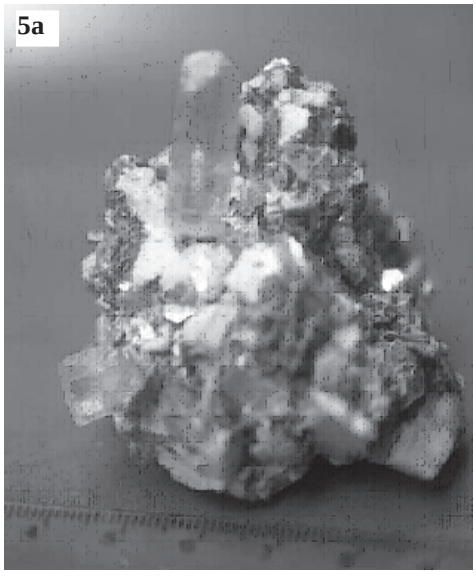
It is not as common as tourmaline, aquamarine and garnet in Nepal. Very few transparent straw-yellow and green coloured topaz are reported only from Rasuwa district. Because of its high hardness and bright colour it is suitable to cut into gems. There is no topaz mine in Nepal.

Semiprecious stones

Semiprecious stones like Tourmaline, Beryl, Aquamarine, Garnet, Spinel, Amazon stone (feldspar), Agate, Jespar, Quartz crystals (smoky quartz, amethyst, citrine, and rock crystals); inky blue Kyanite, etc. are known from Higher and Lesser Himalayan regions of Nepal. Some of the mines are already closed and few of them are in operation (Tables 1 and 2).

Tourmaline

Five distinct types of tourmaline occur in Nepal (Basset 1979). The black tourmaline (schorlite) is commonly recorded in pegmatites, granites, and gneisses but most of them are not suitable for gem cutting. Gem quality distinctive multihued Tourmaline (Elbaite) of Hyakule and Phakuwa areas (UN/ESCAP, with DMG 1993), eastern



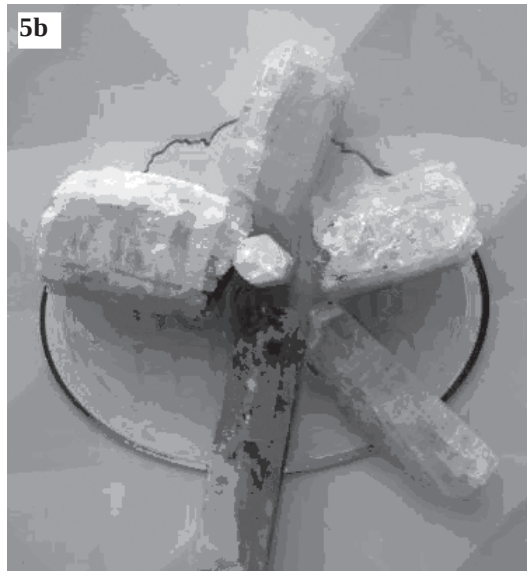


Fig. 5a: Aquamarine from Phakuwa, Sankhuwasabha (DMG 2004). Fig. 5b: Beryl from Taplejung and Manang

Nepal pink (Fig. 3), bright green, light orange sometimes with repeated colour banding olive green with amber coloured core in Hyakule, Sankhuwasabha are known since 1934 Bihar - Nepal earthquake, which triggered landslides and exposed the gem bearing pegmatites. Since then small-scale mines of Aquamarine, Beryl, Tourmaline and Garnet are in operation. It is estimated that over 13,000 kg gem tourmaline has been already mined from Hyakule over a period of five decade (Tamrakar 1990). But at present most of them are closed due to difficult mining condition, unavailability of large size gem quality stones and security reason. Pegmatites of Langtang valley (Rasuwa), Naje (Manang), Garkhakot (Jajarkot), Ikabu and Lodantar (Taplejung) and few places in Panchthar are also promising for tourmaline. Some gem quality green coloured tourmaline bearing pegmatites are known from Jajarkot district and two tourmaline mines at Garkhakot area in Jajarkot are in operation (Fig. 4). Raw gemstones from these areas are mined, cut into proper size and polished for gem for sale. Four prospecting licenses and two mining licenses have been issued/ renewed by DMG in FY2066/67. Tourmaline is mined from two mines but production of tourmaline in 2010 (FY 2066/67) is not known.

Aquamarine and Beryl

Aquamarine and Beryl of Ikabu and Lodantar areas in Taplejung district are highly prized. Similarly, hambergite, danburite, and ijolite are the important ones. In this area, beryl and transparent quartz crystal mines are in operation where as the aquamarine and tourmaline mines are still in development stage. Gem quality clear blue aquamarine of Phakuwa village in Sankhuwasabha district (Fig. 5a), aquamarine/ beryl (Fig. 5b) and few green coloured tourmalines from Naje and few other localities in Manang district (Einfalt et al. 1995), western Nepal are famous. Lekhpatan and Tikachaur in Jajarkot; Jagat, Panchmane, Kagtigaon in Kathmandu; Baguwa, Tarkeghyang, Nibuwagaon in Sindhupalchok, Khaptad (Bajhang), and few places of Darchula and Panchthar are the other known places for Beryl/ Aquamarine. The author along with Dr. Einfalt studied some gem bearing pegmatites in Phakuwa, Hyakule (Sankhuwasabha), Naje (Manang) and author in some parts of Taplejung and Jagat in Kathmandu districts. During field investigation they had also recorded that because of haphazard and illegal mining using explosives, without any technical knowhow in mining the local people in Naje has destroyed the whole pegmatite bodies/ prospect, lots of valuable gems (green Tourmaline and marine blue Aquamarine/ beryl) were lost. Now the chance of recovery of large size crystals is very rare.

Beryl is also a source of beryllium. Beryl/ Aquamarine crystals are cut and used as gem. Attractive colour, brightness, size, shape counts the price of the gemstone. DMG has issued 2 prospecting licenses for Aquamarine. Department of Mines and Geology as well as the local authority should be very careful about the illegal mining activities and destruction of national natural resources and national properties. Present production of Aquamarine and Beryl in 2010 (FY 2066/67) is not known.

Amazon stone/ Amazonite (Feldspar)

Light green coloured Amazon stone (Fig. 6, coloured microcline feldspar) is recorded in the pegmatites of Hyakule and Phakuwa in Sankhuwasabha, Naje in Manang and some parts of Taplejung. The attractive coloured transparent crystals can be cut into gemstone and other ornaments. There is no mineable deposit of Amazon stone known so far, however, since in many cases it occurs together with tourmaline and quartz crystals in pegmatite it can also be mined at the same time.

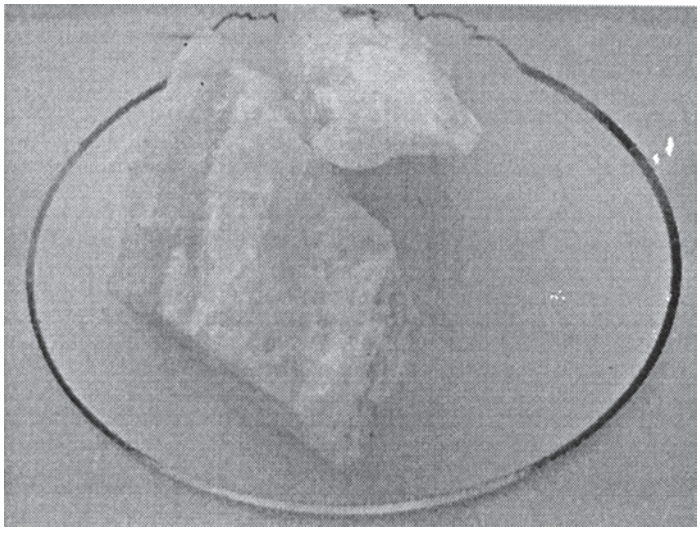


Fig. 6: Amazone stone (Feldspar), Taplejung

Fig.7: Elongated Kyanite crystal, Daha, Jajarkot

Fig. 8a: Garnet crystal and beads made up of Garnet

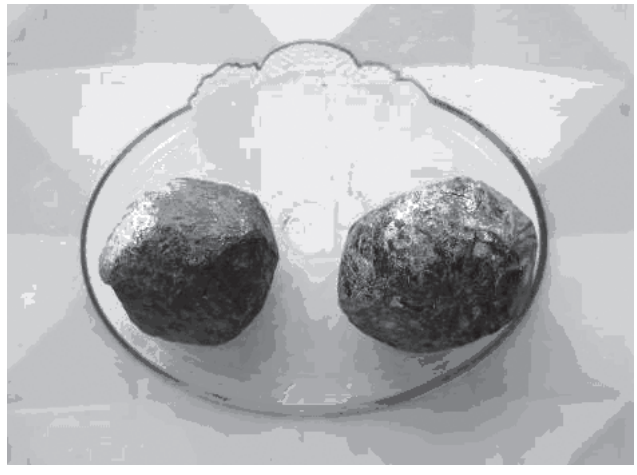


Fig. 8b: Raw Garnet from Sankhuwasabha (Source: DMG Mineralogical Museum, DMG 2000)

Epidote

Elongated light yellowish green or pistacho-green transparent crystals of epidote are recorded in crystalline metamorphic rocks like epidote-garnet-schist, epidote bearing amphibolite, and gneiss in Manang district. There is no epidote mine in Nepal till to day.

Small to fine shining crystals of Zircon, Rutile and Sphene along with garnet, magnetite, ± placer gold are recorded in almost all the heavy concentrate samples from the major rivers of Nepal. They are semiprecious stones but because of their small size they are not used as gemstone.

Kyanite

Kyanites are present in high-grade metamorphic schist and gneiss in the Higher Himalayan regions. They are known mainly from Dolakha, Sankhuwasabha, Taplejung, Rasuwa, Dhading, Bajhang, Jajarkot and Achham districts. Elongated tabular inky blue Kyanite crystals are cut for gems (Fig. 7). They are also used to manufacture spark plugs and other highly refractory porcelains in the industries. Kyanite also has many industrial uses. Four small-scale Kyanite mines are in operation in Daha and Suneri areas in Jajarkot and Barah area of Aachham districts. Only elongated tabular inky blue Kyanite crystals of these areas are cut for gem and the rest are used in various industries. Jaipur of India is the main market of Kyanite and other raw gemstones. DMG has issued 15 prospecting licenses and 4 mining licenses of Kyanite. It is mined from four mines in Nepal but present production of Kyanite in FY2066/67 (Gem grade and Industrial grade) is not known.

Garnet

Almost all the prospective garnets are recovered from strongly tectonized lenses and pods of chlorite-biotite-garnet schist within high-grade metamorphic rock sequence mainly in the Higher Himalayan regions in Sankhuwasabha, Taplejung, Ilam, Dhadhing, Rasuwa, Jajarkot, etc. and few other districts(UN/ESCAP, with DMG 1993). Deep red or red coloured almandine, hessonite and pyrope garnet are

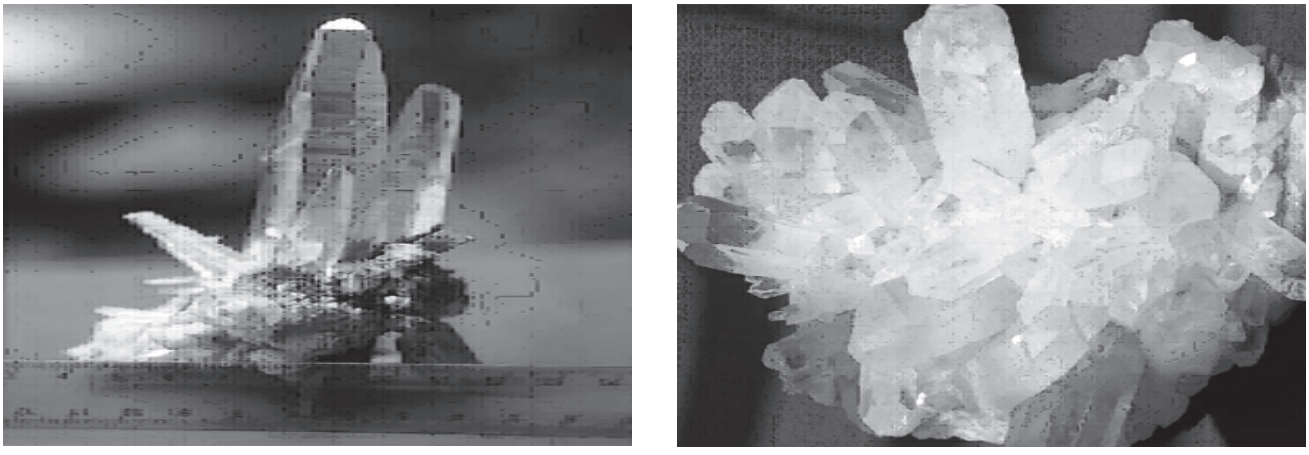


Fig. 9: Quartz crystals (DMG 2004) from Taplejung, eastern Nepal

mined mainly in Sankhuwasabha and Taplejung districts in eastern Nepal. Due to highly fractured nature only selected pieces are cut for gem and the rest are generally used to make beads (Fig. 8a) and abrasive powder. More than six small-scale garnet mines were in operation since last few decades in Budhekhani, Bhote Khola, Hanglaung, Khining, Sunaula, Swachi Khani in Sankhuwasabha district, Eastern Nepal (Fig. 8b). At that time of the production of raw garnet was up to 37mt till 1985. However, at present none of them are in operation due to lack of technical knowhow, difficult mining condition and security reason. At present only one prospecting license has been issued by DMG.

Quartz crystals (Rock crystal)

Quartz is a common rock-forming mineral. Quartz crystals are known from the pegmatites located in different parts of Taplejung, Ilam, Sankhuwasabha, Nuwakot, Dhading, Rasuwa, Manang, Dailekh, Jajarkot and Darchula districts. Smokey Quartz crystal, rose/ pink quartz (Amethyst), yellow quartz (Citrine) and colourless perfect clear crystal (Rock crystal) are the gem variety that are available in Nepal. They are very good to cut and polish for gems. Colourless quartz crystals (Fig. 9) and dog tooth spar are also used as decorative pieces and export to foreign countries.

At present only two small-scale quartz crystals mines are in operation in Khejemi/ Sirku (Taplejung) and Raluka (Nuwakot)**.** High-grade quartz (SiO2 >99%) is used for ferrosilicon production. Industrial application of quartz is in foundry, as flux in still mill, chemicals, refractory, fillers, glass manufacture, sandblast, abrasive etc. Perfect clear quartz crystals without any cracks and inclusions are used in optical apparatus and control the frequency of radio circuits. From DMG record two quartz mines are in operation/ production but present production of Quartz crystals (Gem quality and Industrial quality) in 2010 (FY2066/67) is not known.

Jasper

It is cryptocrystalline quartz usually with red colour due to hematite inclusions. Jasper is not mined so far in Nepal. However, it has been recorded in the heavy concentrate samples collected from major rivers.

Agate

It is a variegated variety of chalcedony with nice looking alternating layers of chalcedony and opal. It is recorded at very few places in Sankhuwasabha and Taplejung districts. But they are not yet mined due to their very small occurrences. Present production of agate is not known.

GEMSTONE INDUSTRIES

In 1985 Dr. A.M. Basset introduced the first modern faceting (cutting and polishing) machine in Nepal and started cutting the local gemstones. In the following years few lapidary works and gem shops were opened in Kathmandu. At present registered gem cutting and polishing industries like (1) Himali Ratna Udyog, Dharan, eastern Nepal (2) Himalayan Gems, Nepal Pvt. Ltd., Kathmandu (3) Birendra Thakali, Pokhara (4) Mohan Shrestha, Kathmandu (5) Udaya Tamrakar, Kathmandu (6) Kohinoor gem industry, Kathmandu etc. are the main ones which are in operation in Nepal (Kaphle, 2003). Now a day a number of gem shops are running their business mainly in Kathmandu, Pokhara and other major cities.

GEMSTONE MINES AND THEIR PRODUCTION

There is a sharp irregularity in gemstone mining and production in Nepal. The Mining Lease holders did not show regular production in exact amount as they mined every year and suddenly they leave mining activities. Although the Himalayan Gems are very famous and their demand is very high in the international market but the production is very low and could not fulfill the demand. Available data on the raw gemstone production shown by the lease holders to DMG in different year are presented in the Tables 1 and 2

Table 1: Exploration and operating mines of gemstones in Nepal (FY2066/67 BS / 2009/2010)

Mineral Commodity	Location & Number of deposits	Prospects/ Deposit in exploration stage and Prospecting License	Operating Mines/ and Mining License	Preset status Exploration/ Mining	Production from the mines
Ruby/ Corundum	Dhadhing and Rasuwa	1 prospecting license issued	No record	**NK**	NK
Sapphire	Dhadhing and Rasuwa	No license issued	No record	**NK**	NK
Aquamarine/ Beryl	Sankhuwasabha-1 Taplejung-1	2 Prospecting licenses issued	No record	2 Exploration stage	No production
Tourmaline	Jajarkot-2 Sankhuwasabha-2	10 Prospecting license issued	- Barabise (Sankhuwasabha) -1 - Garkhakot (Jajarkot)-1,	2 Mines in operation 4 Exploration stage	GQ= NA IQ=NA
Kyanite	Jajarkot-3 Achham-1	15 prospecting license issued	- Daha (Jajarkot) - 3 - Achham-1	4 Mines in operation 15 Exploration stage	GQ=NA IQ=NA
Garnet	Sankhuwasabha-1	1 Prospecting license issued	No record	1 Exploration stage	No production
Quartz crystal	Khajenim (Taplejung,)-1 Raluka (Nuwakot)-1	8 Prospecting license issued	-Khajenim (Taplejung) - 1 - Raluka (Nuwakot) -1	2 Mines in operation 8 Exploration stage	GQ=NA IQ=NA

Table 2: Gemstone (Raw) production in Nepal in last 23 years (From 1988 to 2007)

Production year	Ruby & Sapphire	Tourmaline	Aquamarine & Beryl	Garnet	Kyanite	Quartz crystal	Remarks/ Total Production
1988	NA	**GQ=1.9kg IQ=20.2kg**	**GQ=10kg IQ=390kg**	NA	NA	NA	Total=GQ=11.9kg IQ=410.20kg
1989	NA	NA	**900kg**	NA	NA	NA	Total=900kg
1990	NA	**GQ=200kg IQ=2mt**	**GQ=50g IQ=0.5mt**	GQ=NK IQ=NK	GQ=NA IQ=NA	**12.5mt**	Total= GQ=250kg IQ=15mt
1991	NA	GQ=500kg IQ=4mt	NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**10.62mt**	Total = GQ=500kg IQ=14.62mt
1992	NA	**GQ=100kg IQ=1mt**	NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**6mt**	Total = GQ=100kg IQ=7mt
1993	NA	**GQ=250g IQ=0.25mt (?)**	**GQ=250g IQ=0.25mt (?)**	GQ=NK IQ=NK	GQ= NA IQ= NA	**5mt**	Total = GQ=500kg IQ=5.5mt (?)
1994	NA	**GQ=NA IQ=NA**	NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**2.204mt**	Total= GQ=NA IQ=2.204mt
1995	NA	**GQ=250kg IQ=2.05mt**	NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**1.864mt**	Total = GQ= 250kg IQ= 3.914mt
1996	NA	**GQ=950kg IQ=2.95mt**	NA IQ= NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**1.5mt**	Total = GQ= 950kg IQ= 3.45
1997	NA	**GQ=500kg IQ=5mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**3mt**	Total = GQ= 500kg IQ= 8mt
1998	NA	**GQ=500kg IQ=20mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**2mt**	Total = GQ= 500kg IQ= 22mt
1999	NA	**GQ=500kg IQ=10mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	GQ= NA IQ= NA	**3.2mt**	Total = GQ= 500kg IQ= 13.2mt
2000	NA	**GQ=10kg IQ=1mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	GQ= NA IQ= NA	NA	Total = GQ= 10kg IQ= 1mt
2001	NA	GQ=NA IQ=NA	GQ= NA IQ= NA	GQ=NK IQ=NK	GQ=1000kg IQ=10mt	1.13mt	Total = GQ= 1000kg IQ= 11.13mt
2002	NA	GQ=NA **IQ=2mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	**GQ=1004kg IQ=9.4mtmt**	**GQ=1720kg IQ=172mt**	Total = GQ= 2724kg IQ= 183.4mt
2003	NA	**GQ=1100kg IQ=11.5mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	**GQ=420kg IQ=3.8mt**	**GQ=1765kg IQ=176mt**	Total = GQ= 3285kg IQ= 191.3mt
2004	NA	GQ=NA IQ=NA	GQ= NA IQ= NA	GQ=NK IQ=NK	**GQ=1150kg IQ=10.4mt**	**GQ=1215kg IQ=121mt**	Total = GQ= 2365kg IQ= 131.4mt
2005	NA	**GQ=700gm IQ=7mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	**GQ=2880kg IQ=26.82mt**	**GQ=1092kg IQ=109.2mt**	**Total=GQ4672kg IQ=133.02mt**
2006	NA	**GQ=660kg IQ=6.6mt**	GQ= NA IQ= NA	GQ=NK IQ=NK	**GQ=2300kg IQ=20.7mt**	**GQ=949kg IQ=9.49mt**	**Total= GQ=3.91kg IQ=36.79mt**
2007	NA	GQ= NA IQ= NA	GQ= NA IQ= NA	GQ= NA IQ= NA	GQ=NA IQ=NA	GQ=NA IQ=NA	**Total GQ= 2715kg IQ= 21.19mt**

below.

CONCLUSION AND RECOMMENDATION

It is very clear from the published documents, reports and existing available information from different sources that there are a number of gemstone prospects in Nepal Himalaya. Till this time only surfacial study of few gemstone occurrences has been done based on the saying of the local people. Therefore available valuable gemstone (precious and semiprecious stones) resource remained unexplored and unexploited. Therefore, a special team should be managed to asses all the available information and do field mapping as well as gemstone exploration in the geologically most prospective areas in the Higher Himalayan as well as in the Lesser Himalayan regions is urgently need to identify the economic deposits.

Government should be very strict and give heavy punishment to those who is running illegal and haphazard mining activities to save the national valuable natural resources available in the country. Exploration or mining license should be given only to those entrepreneurs who have the technical manpower and proper equipment for gem mining. Regular checking from the local authority, and inspection, monitoring and supervision by the Department of Mines and Geology to know the mining condition, equipment and man power used, safety measure, methodology applied, and the quantity of production, environment issues etc. to flourish gemstone of the country.

DMG should regularly publish all the updated information/ data on the exploration license, mining license, and annual production of different mineral commodities and also highlight on the possibility of national and international market so that government can attract interested entrepreneurs/ private companies to invest in mineral exploration, development and mining sector.

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Exploration of cement-grade limestone at Masrang, Chitwan District, central Nepal

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ABSTRACT

Geological mapping, chemical analysis and reserve estimation were carried out in the limestone deposit at Masrang, Chitwan district, central Nepal. The Masrang Limestone Deposit is geologically located at the western closure of the Mahabharat Synclinorium in Jhiku calcareous beds of the Benighat Slate, Nawakot Complex, central Nepal. There are two prominent bands of limestone at Masrang Gaon and Dhala Gaon. Petrographic study shows that the limestone is composed of microcrystalline calcite with minor amount of mica, chlorite and quartz. Chemically, the limestone is homogenous in nature, with CaO content more than 49% and MgO less or equal to 1%. Geological reserve of the deposit is approximately 11 million tones. Therefore, further studies on the limestone deposit for exploitation are recommended.

Keywords: Chemical analysis, Masrang Limestone Deposit, Jhiku calcareous beds, central Nepal

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INTRODUCTION

Prospecting and exploration of limestone have been carried out in Nepal since 1960's, which have resulted in establishment of few cement industries and have shown the prospects for a large exploitation of cement in various parts of the country. About 1.25 billion tons of limestone deposits have been estimated in the country and occupy an area of 7000 sq. km. Limestone of different geological ages from Late Precambrian to Eocene is known from the Lesser and Tibetan-Tethys Himalayas. However, the Late Precambrian and Cambro-Ordovician limestones have been identified as main sources of cement production. Almost all of them lie in the Lesser Himalaya.

In the present study geological mapping and chemical analyses were carried out for the limestone bands of Jhiku calcareous beds, Benighat Slate of Nawakot Complex at Masrang, Chandibhanjyang Village Development Committee, Chitwan District of central Nepal. It is located at the southeast of Mugling (Fig. 1) and can be accessed by a trail from Jalbire village. This paper presents the results and recommendations for further studies to be carried out in exploitation of limestone.

GEOLOGICAL SETTING

The Jhiku calcareous bed of the Masrang Limestone Deposit is a member of the Benighat Slate, Nawakot Complex located at the western limb of the Mahabharat Synclinorium (Stöcklin and Bhattarai 1977) at its westernmost closure (Fig. 2). The thickness of the Benighat Slate containing Jhiku calcareous beds of Paleozoic age varies from one location to another, i.e., 500-3000 m. The Benighat Slate consists of dark gray, easily weathering slates and phyllites, is mainly of argillaceous nature and with subordinately siliceous or fine grained quartzites intercalated. The colour of the quartzites is bluish grey to nearly black. Greenish gray colour of the slate is primarily due to the presence of chlorite.

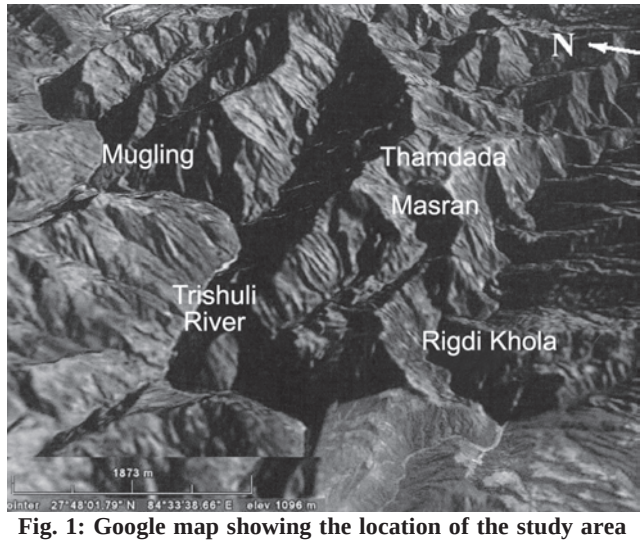

Fig. 1: Google map showing the location of the study area

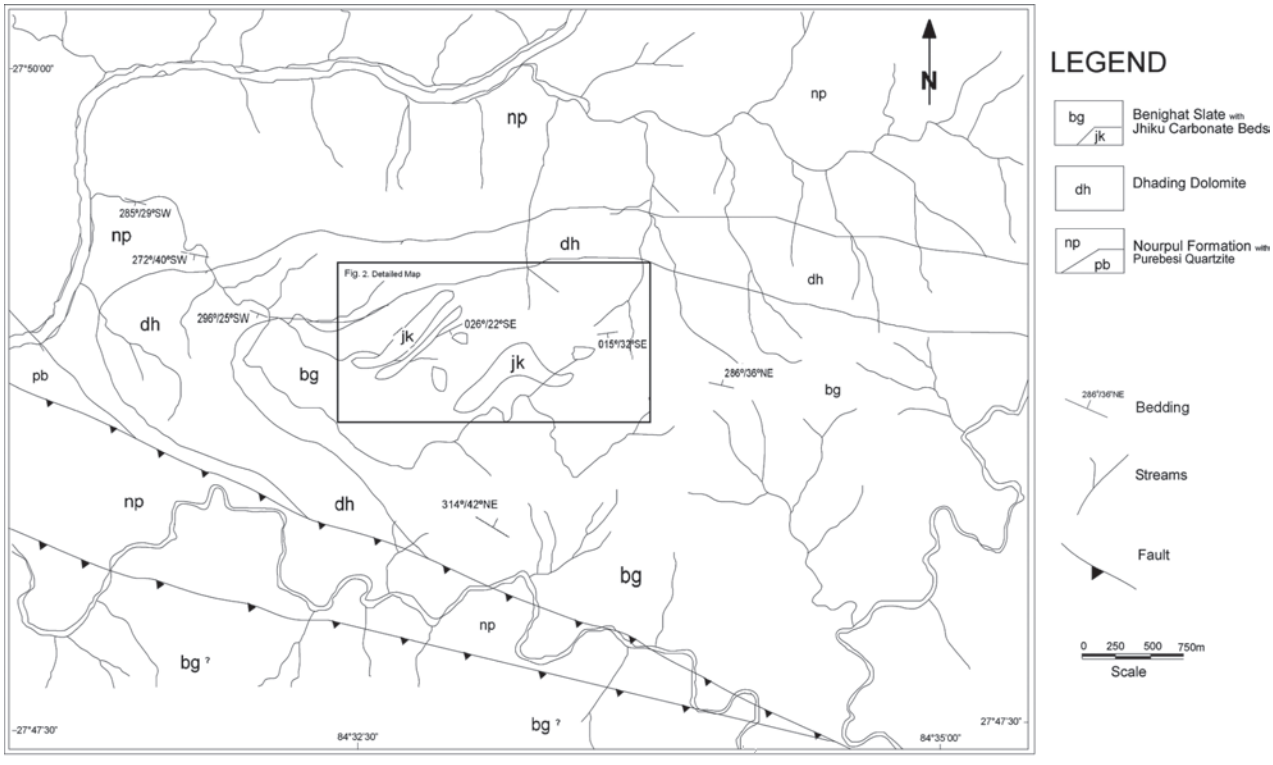

Fig. 2: Geological map of the Masrang area (after Stöcklin and Bhattarai 1977)

At the Masrang Limestone Deposit and towards its contact with the underlying Dhading Dolomite, slates are more phyllitic with greenish gray colour. Stratigraphically up-section of the deposit, black colour slates are more dominant.

The Jhiku calcareous beds are calc-phyllites and phyllitic limestones or even dolomites. These calcareous beds form irregular intercalating lenticular in shape in the Benighat Slate. Limestone beds of the Masrang Limestone Deposit are inter-fingering with slates and phyllites with average thickness of 40 m and are distributed at different stratigraphical levels within the Benighat Slate. Limestone beds, even with relatively higher carbonate content, have usually phyllitic nature. Thinly bedded limestone is quite common for the Masrang Limestone Deposit, thickness of which ranges from 5 to 25 m. They are found at Masrang Khola-Masrang Gaon and Dhala Gaon, north of the Seti Khola. Limestone beds of the deposit are dipped along the south east direction, with an attitude of 015˚/30˚ SE.

Prominent limestone bands were identified at two locations, Masrang Gaon and Dhala Gaon. At Masrang Gaon, the deposit consists of two sub-bands of limestone, which are sandwiched between quartzites and phyllites of the Benighat Slate (Fig. 3). Limestone beds extend to about 700 m and average thickness is about 50 m. At Dhala Gaon, there are at least five bands. Each band is sandwiched between quartzites and phyllites.

Limestone is light to dark grey, fine crystalline, jointed and weathered. Swelling and pinching of limestone is common in the Jhiku calcareous beds at Dhala Gaon. General extension of the limestone deposit is SW in direction and dip amount ranges from 30˚ to 50˚ SE. The average thickness of the limestone is 30 m and laterally extends 500 m. The general attitude of the limestone beds is 230°/28° SE.

The foot wall of the Masrang Limestone Deposit is represented by slates and phyllites. Phyllite is greenish gray in colour due to the presence of chlorite. Phyllites and slates are calcareous due to presence of small beds of limestone and marl beds. Slate is fine grained, dark in color. The roof wall of the Masrang Limestone Deposit comprises of fine grained, carbonaceous slates of the Benighat Slate. Fresh slates, observed along the confluence of the Seti Khola and the Masrang Khola, are dissected by intricate network of thin quartz veins and boudinage. Slates are calcareous in some places as they contain thinly 1 to 5 cm thick bed of limestone. Thin limestone beds cannot be economically mined which make them foot wall of the deposit. 10 mm to 2 cm thick quartz veins are regularly present within the slates. The attitudes of bed are approximately 210°/52°SE.

Table 1: Chemical analyses of grab samples

S.N.	Sample no.	Parameters and units						
		LOI (% w/w)	Insoluble (% w/w)	R_2O_3 (% w/w)	Fe_2O_3 (% w/w)	Al_2O_3 (% w/w)	CaO (% w/w)	MgO (% w/w)
1	MT-1	42.37	1.44	0.31	0.24	0.07	44.29	0.79
2	MT-2	42.10	1.58	0.35	0.28	0.08	53.47	1.77
3	MT-3	42.36	2.45	0.35	0.32	0.05	52.67	0.39
4	MT-4	42.20	3.24	0.38	0.22	0.03	53.59	0.40
5	MT-5	42.45	2.55	0.33	0.21	0.06	51.72	0.38
6	MT-6	42.86	2.60	0.35	0.24	0.08	52.62	0.40
7	MT-7	42.20	2.27	0.33	0.24	0.09	52.03	1.01
8	MT-1-A	42.71	2.90	0.33	0.21	0.11	53.64	1.08

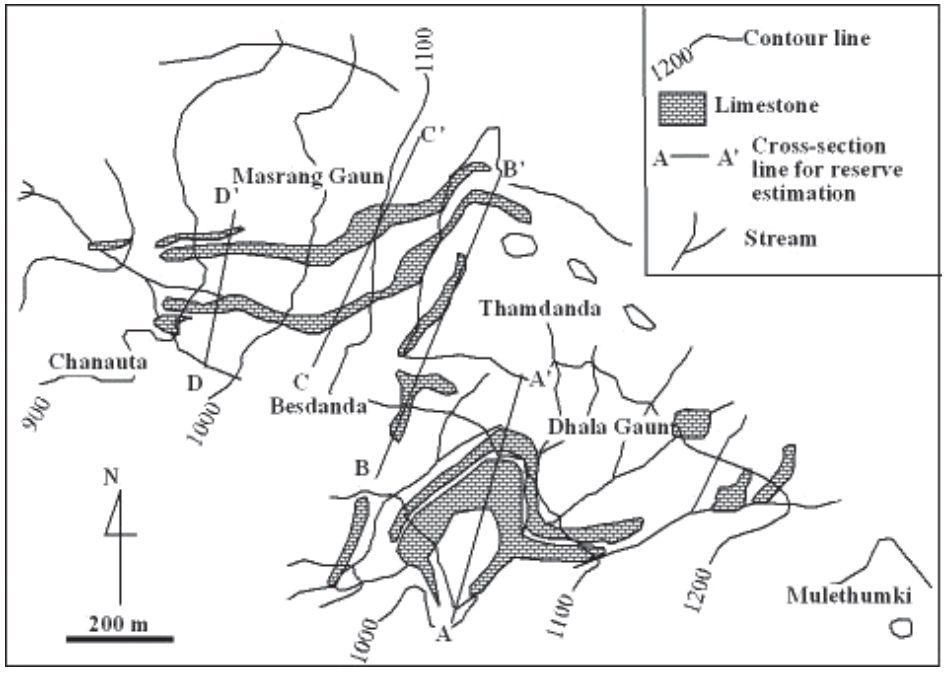

Fig. 3: Geological map of the Masrang Limestone deposit

MICROSCOPIC STUDY

Some representative samples of limestone were studied in thin section. Crystalline calcite grains of size between 0.2 - 20 μm are cemented by crystalline (primarily finely crystalline with grain size less than 0.01 mm) and occasionally amorphous colloidal and other chemogenic calcite.

In the analyzed thin sections, the visual microscopic fields are mostly covered by calcite crystals with few grains of quartz. The limestone is finely crystalline and slightly siliceous. The studies of the samples in thin-sections from Masrang deposit show the samples contain the dominance of calcite minerals. Calcite constitutes 75 to 90% of the total mineral content and quartz accounts about 4 to 8%, and biotite and other minerals are found as accessory minerals (less than 2%). General texture of calcite is crystalline. In samples of limestone at Dhala Goan, calcite mineral is dominant, ranging its content from 85 % to 90 % of total mineral content and rest minerals are quartz, biotite, muscovite, etc.

RESULTS OF CHEMICAL ANALYSIS

Eight grab samples were taken from the Masrang and Dhala Gaon limestone deposits for chemical analysis.

During the chemical analyses of limestone, loss of ignition, insoluble mineral, Al_2O_3, Fe_2O_3, CaO and MgO content were calculated from the grab samples (Table 1).

The analysis shows that all the samples contain CaO more than 44% and MgO is less than 2% confirming their cement grade quality **(**Pandey and Baskota 2008).

Table 2: Reserve calculation

SN	Section along	Total cross-section area(m^2)	Total area of limestone(m^2)	Strike length(m)	T.F.	Total Geological Reserve(tonnes)	Area of Overburden Section(m^2)	Volume of Overburden (m^3)
1	A (SW) – A'(NE)	52579	5907	200	2.6	3071640	3689	737800
2	B (SW) – B'(NE)	103676	21442	80	2.6	4459936	40775	3262000
3	C (SW) – C'(NE)	61967	9990	80	2.6	2077920	13745	1099600
4	D (SW) – D'(NE)	14563	3567	80	2.6	741936	2786	222880
5	E (SE) – E'(NW)	15885	3377	50	2.6	439010	3312	165600
Total		248670	44283			**10790442~11mT**	64307	**5487880~5.5 mT**

LIMESTONE RESERVE

Vertical cross-sectional method was used to calculate the economic reserve. Five cross-sections (AA', BB', CC', DD' and EE', Fig. 3) were prepared across the strike of the Masrang Limestone Deposit with referencing to the sampling points. The area was calculated by simple geometrical method and the strike length was taken from the geological map at the scale of 1:2000 (Fig. 3). The total geological reserve was calculated to be approximately 11 million tons (Table 2). This calculation does not consider karstification and other relevant factors since there were no evidences as such in the exposed surfaces.

CONCLUSIONS AND RECOMMENDATIONS

The Masrang Limestone Deposit is located in the western closure of the Mahabharat Synclinorium, central Nepal. Stratigraphically, the limestone deposit belongs to the Jhiku calcareous beds of the Benighat Slate, Nawakot Complex. There are two prominent bands of limestone at Masrang Gaon and Dhala Gaon, Chitwan District. Petrographic study shows that the limestone is composed of microcrystalline calcite with minor amount of mica, chlorite and quartz. Chemical analysis of grab and channel samples show that the limestone contains more than 44% CaO and MgO is less than 2% with cement grade. The reserve of limestone is about 11 million tones. Based on the preliminary study, further detailed studies in the area for exploitation of limestone are recommended.

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Contrasting metamorphic history of the Higher Himalaya and the Main Central Thrust zone, Nepal Himalaya recorded in garnet porphyroblasts

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ABSTRACT

Garnet porphyroblasts are very good recorders of metamorphic evolution of an orogenic belt. They are formed deeply in the crust during metamorphism and their composition continuously evolves during uplift and exhumation. Himalayan metamorphic belt (Higher Himalaya, Main Central Thrust zone and the Lesser Himalayan crystalline nappes) comprise pelitic and psammitic schists and gneisses with abundant garnet porphyroblasts. Chemical analysis of those porphyroblasts from those units in the Arun Valley (east Nepal), Pokhara area (central Nepal) and Jajarkot area (west Nepal) shows that the Higher Himalayan and the MCT zone rocks experienced a contrasting metamorphic history. The chemical composition of the garnet porphyroblasts of the Higher Himalaya experienced an Eohimalayan prograde peak metamorphism followed by the Neohimalayan retrogression. The MCT zone and the Lesser Himalayan crystalline nappes experienced a Neohimalayan prograde dynamo-thermal metamorphism followed by late-stage retrogression during uplift and exhumation. Garnet compositional similarity between the Jajarkot Klippe and the MCT zone indicates that the Lesser Himalayan klippe most probably roots to the MCT zone.

Keywords: Garnet, Eohimalayan metamorphism, Neohimalayan metamorphism, MCT zone, Higher Himalaya, Nepal Himalaya

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INDRODUCTION

Metamorphic minerals are formed deeply in the crust and are subsequently exhumed to the surface of the earth by tectonic and erosional processes (Miyashiro 1973). The metamorphic minerals record not only pressure-temperature condition but also deformational history during exhumation. The deformation history of the orogenic belt is recorded in textures, and pressure-temperature history is recorded in chemical composition of the mineral. Therefore, textural and mineral chemical studies are keys to understand the tectono-metamorphic evolution of an orogenic belt.

Garnet is one of the most important minerals recording such a tectono-metamorphic history where metamorphism has reached higher than green-schist facies. Garnet usually displays chemical zoning. Zoned garnet in metamorphic rocks can be thought of as a chemical tape recorder in which history of chemical reaction in a rock, and hence its P-T history, are recorded (Spear 1993).

In the Nepal Himalayas, the metamorphic rocks are exposed along one of the plate boundary branch thrusts, the Main Central Thrust (MCT). The MCT is a ductile shear zone of about 3 km thickness (Pêcher 1977). The upper bounding thrust of the ductile shear zone is known as the Upper MCT and the lower bounding thrust is known as the Lower MCT (Paudel and Arita 2000). The zone between these two thrusts is known as the MCT zone (Fig. 1). The Higher Himalaya thrusts on the Lesser Himalaya along the Upper MCT.

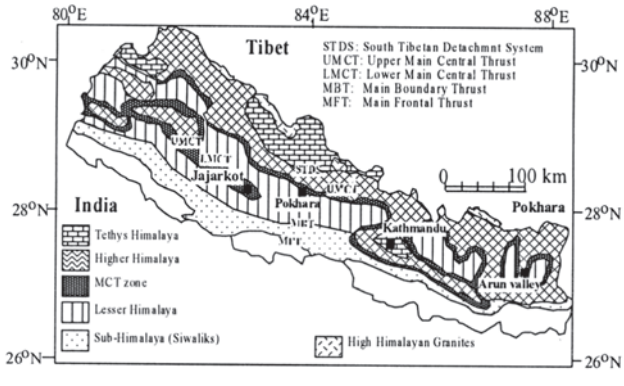

Fig. 1: Geological map of the Nepal Himalaya showing the location of the study area

Metamorphic rocks of medium to high grade are well exposed both in the Higher Himalayan root zone, MCT zone

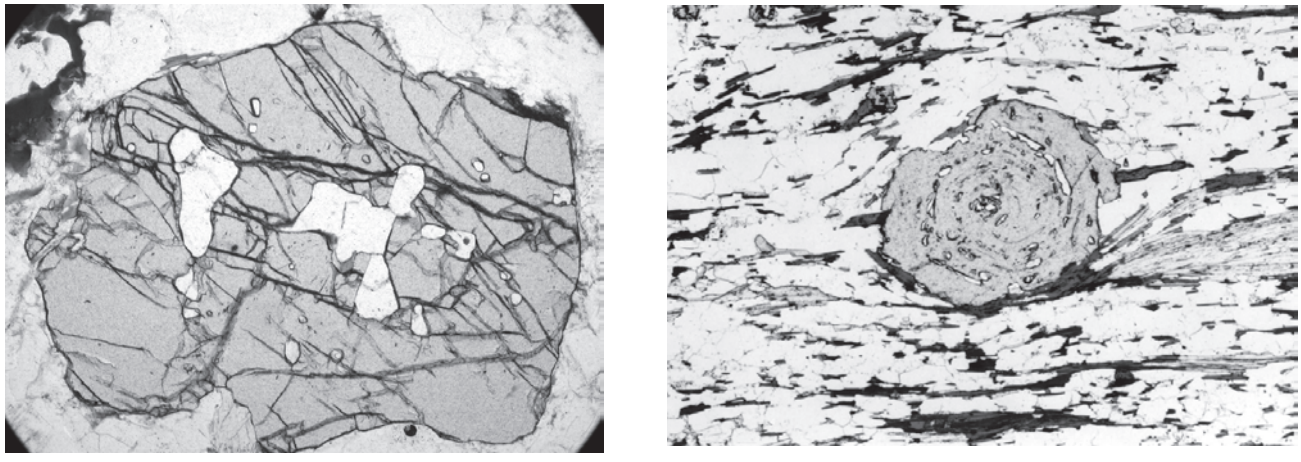

Fig. 2: Photomicrographs showing differences in microstructures between the garnets of the Higher Himalaya (a) and the MCT zone (b)

and the Lesser Himalayan nappes. In the present paper, the textural features and chemical compositions of garnet from the Higher Himalaya and MCT zone from some sections of the Nepal Himalaya show contrasting metamorphic evolution between the Higher and the Lesser Himalayas.

LITHOLOGY AND DESCRIPTIONS OF SAMPLES USED FOR ANALYSIS

The Higher Himalaya comprises metamorphic crystalline rocks of amphibolite to granulite facies. This Himalaya is divided into three formations (Le Fort 1975). From bottom to the top they are Formation I, Formation II and Formation III. The Formation I is about 800 m thick and composed of banded gneisses of pelitic to aranaceous origin. The Formation II is mainly composed of pyroxene- and amphibole-bearing calc-gneisses and marble. This unit is about 3000 m thick. The Formation III is made up of coarse-grained augen gneiss of igneous origin. This unit is about 1300 m thick. The MCT zone comprises greenschist to epidote-amphibolite facies rocks of sedimentary and igneous origin. They are mainly pelitic schists, psammitic schists, augen gneisses, calc-gneisses, marbles and metabasites.

Samples of garnet-bearing pelitic and psammitic schists and gneisses were collected from the Higher Himalaya and the MCT zone of the Pokhara area (central Nepal), Jajarkot Klippe (western Nepal) and the Arun valley (eastern Nepal) (Fig. 1). Well developed garnet porphyroblasts are found in the samples. Thin sections were prepared from the samples, parallel to the stretching lineation and perpendicular to the foliation and were examined under petrological microscope.

MICROSTRUCTURES IN GARNET PORPHYROBLASTS

The samples from the Higher Himalaya show granoblastic texture with variable grain size (1 mm to 10 mm in diameter). Garnets reach up to 1 cm in diameter. They are usually poikiloblastic with inclusion-rich core and inclusion-free rim (Fig. 2a). The inclusions are mainly quartz, and rarely biotite and opaques. Garnets from the MCT zone show spiral inclusions forming a “snowball structure” (Fig. 2b) which is also known as syn-kinematic growth structure (Schoneveld 1974). This texture is one of the specific features of the garnets from the MCT zone. The garnets from the Higher Himalaya are usually elongated and wrapped up by foliation indicating that they were pre-tectonic. Garnets from the MCT zone show mainly syn- to post-tectonic growth.

CHEMICAL COMPOSITION

Garnets from the Higher Himalaya and MCT zone of the Pokhara area (central Nepal), Jajarkot Klippe (western Nepal) and the Arun valley (eastern Nepal) (Fig. 1) were analysed at cores and rims. Compositional profiling for Mn-, Ca- and Mg-contents was done for the large porphyroblasts. Analysis was made by the JEOL Superprobe 733 (specimen current 200 mA, accelerating voltage 15 kV, natural and synthetic silicates and oxides as standards) at the Faculty of Science, Hokkaido University, Japan. All the raw data were corrected using conventional ZAF correction procedures.

Representative analytical data are given in Table 1 (Pokhara area), Table 2 (Jajarkot area) and Table 3 (Arun Valley). The compositional patterns of garnets from different sections are described below.

Garnets from the Higher Himalaya

Garnets from the Higher Himalaya are relatively rich in pyrope (Mg) content and poor in spessartine (Mn) content (Figs. 3a and 3c) compared to that in the MCT zone. In the Pokhara area, the Mg-content in the cores ranges from 14-24% and that in the rim ranges from 12-18% (Table 1). Similarly Mn-content in the cores ranges from 3-5% and

that in the rims ranges from 3-7%. Sample from the Arun valley shows Mg-content of 12% in the core and 10% in the rim.

Compositional profiling reveals that garnets from all the sections are characterized by a flat compositional plateau at the cores (Fig. 4a). However, the zoning patterns differ from grain to grain. Some grains show homogeneous cores and retrograde rims. The Fe- and Mn-contents increase and the Mg-content decreases towards the rims in those grains (Fig. 3a). Some grains have homogeneous cores and prograde rims. The Ca-, Mg- and Fe-contents increase and Mn-decrease towards the rims in those grains.

Garnets from the MCT zone

Garnets from the MCT zone are relatively rich in Mn- and Ca-contents compared to those from the Higher Himalaya (Tables 1, 2, and 3). Almost all of the garnets from the MCT zone of the Pokhara area, Jajarkot area and the Arun Valley have Mn-rich/Fe-poor cores and Mn-poor/Fe-rich rims (Figs. 3 and 4). The Fe-content ranges from 60-76% in the cores and 66-79% in the rims of garnet from Pokhara area. Similarly, the Mn-content ranges from 8-17% in the cores and 2-15% in the rims of the garnet from the area (Table 1). In the samples from the Jajarkot Nappe, the Fe-content ranges from 52-65% in the cores and 65-72% in the rims and Mn-content ranges from 6-20% in the cores and 5-11% in the rims (Table 2). In the samples from the Arun Valley, Fe-content ranges from 64-75% in the cores and 73-79% in the rims. The Mn-content ranges from 0-15% in the cores and 0-5% in the rims (Table 3).

Garnets from the MCT zone show bell-shaped profiles, with Fe gradually increasing and Mn decreasing towards the rims (Figs. 4b, 4c and 4d). Such profiles are typical of prograde growth zoning (Spear 1993). However, the profiles are reversed at the outermost part of the porphyroblasts. It may be due to late-stage retrogression of the rims (Barker 1990).

CONTRASTING METAMORPHIC HISTORY OF THE HIGHER HIMALAYA AND THE MCT ZONE

The microstructures and compositions of the garnet porphyroblasts indicate a contrasting metamorphic history of the Higher Himalaya and the MCT zone. Compositional patterns of garnets from the Higher Himalaya reflect a complex history of growth and diffusion. The garnet profiles

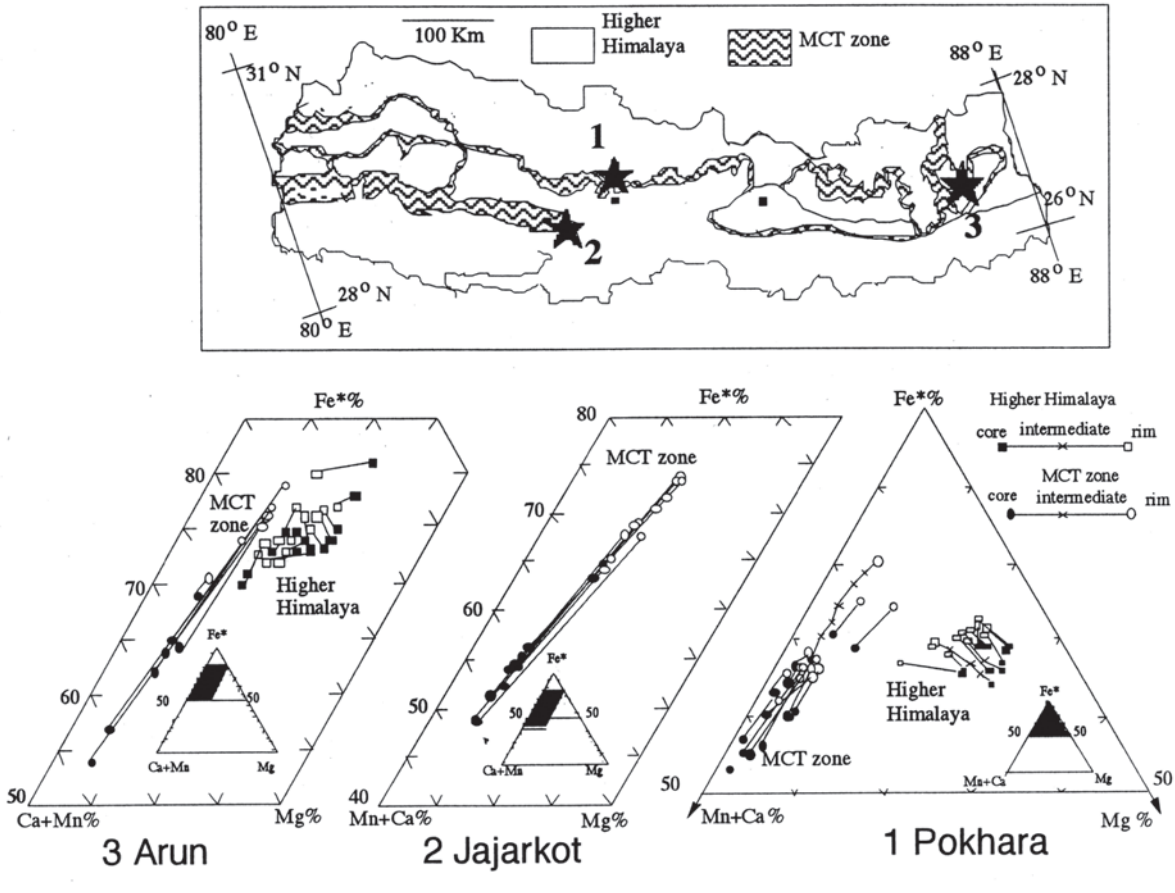

Fig. 3: Compositions of garnets from the Higher Himalaya and the MCT zone. (a) Arun Valley, east Nepal, (b) Jajarkot Nappe, west Nepal and (c) Pokhara area, central Nepal

Table 1: Compositional data of garnets from the Pokhara area

	Higher Himalaya						MCT zone									
Sample No.	158b	158b	158a	158a	176	176	155	155	152a	152a	140c	140c	140b	140b	139	139
Analysed position	Core	Rim	Core	Rim	Core	Rim	Core	Rim	Core	Rim	Core	Rim	Core	Rim	Core	Rim
SiO_2	38.31	38.21	38.42	38.88	38.59	38.31	37.74	37.85	38.23	37.71	37.18	37.83	37.10	37.29	37.70	37.72
TiO_2	0.05	0.07	0.02	0.00	0.01	0.04	0.06	0.09	0.10	0.03	0.10	0.09	0.06	0.01	0.00	0.00
Al_2O_3	21.92	21.50	21.44	21.86	21.56	21.54	21.24	21.64	21.19	21.26	20.98	21.20	21.03	21.14	21.29	21.20
FeO*	31.17	31.74	30.35	30.81	30.39	30.47	27.25	29.86	34.91	34.81	28.83	30.61	28.30	35.14	29.89	34.72
MnO	2.24	2.99	1.82	2.48	1.17	1.27	3.39	0.79	1.61	1.60	7.48	6.63	5.25	0.98	5.51	3.17
MgO	6.41	4.72	5.35	4.49	3.50	3.10	0.87	0.93	1.48	1.83	1.36	1.30	0.65	0.94	0.64	1.05
CaO	1.92	1.87	3.54	3.21	6.10	6.34	10.07	10.07	5.23	4.58	4.63	3.71	7.84	5.00	6.31	3.20
Total	102.02	101.09	100.96	101.74	101.32	101.06	100.68	101.30	102.82	101.82	100.55	101.38	100.29	100.57	101.34	101.05
Cations for 12 oxygens																
Si	2.53	2.57	3.00	3.021	2.59	2.58	2.57	2.57	2.57	2.56	2.56	2.59	2.56	2.58	2.58	2.60
Ti	0.00	0.00	0.00	0.000	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Al	1.71	1.71	1.98	2.002	1.70	1.71	1.71	1.73	1.68	1.70	1.70	1.71	1.71	1.72	1.72	1.72
Fe*	1.72	1.79	1.98	2.003	1.70	1.72	1.55	1.69	1.96	1.98	1.66	1.75	1.63	2.03	1.71	2.00
Mn	0.12	0.17	0.12	0.163	0.07	0.07	0.20	0.05	0.09	0.09	0.44	0.38	0.31	0.06	0.32	0.19
Mg	0.63	0.47	0.62	0.521	0.35	0.31	0.09	0.09	0.15	0.19	0.14	0.13	0.07	0.10	0.07	0.11
Ca	0.14	0.14	0.30	0.267	0.44	0.46	0.73	0.73	0.38	0.33	0.34	0.27	0.58	0.37	0.46	0.24
Total	6.85	6.85	8.01	7.98	6.85	6.86	6.85	6.86	6.84	6.85	6.85	6.86	6.85	6.86	6.86	6.86
Almandine (%)	66	70	66	68	67	67	60	66	76	76	64	69	63	79	67	79
Spessartine (%)	5	7	4	6	3	3	8	2	4	4	17	15	12	2	12	7
Pyrope (%)	24	18	21	18	14	12	3	4	6	7	5	5	3	4	3	4
Grossular (%)	5	5	10	9	17	18	29	29	15	13	13	11	22	14	18	9

Feo* means FeO+Fe2O3

Table 2: Compositional data of garnets from the Jajarkot area

	MCT zone					
Sample No	1507	1507	11407	11407	11402	11402
Analyzed position	Core	Rim	Core	Rim	Core	Rim
SiO_2	38.42	38.02	37.82	37.95	37.82	38.03
Al_2O_3	21.07	21.24	21.04	21.19	21.25	21.64
FeO*	23.41	28.87	26.07	32.00	28.86	31.56
MnO	9.04	4.92	4.85	2.30	4.41	2.03
MgO	1.17	1.86	1.39	2.29	1.49	2.05
CaO	7.80	5.45	8.92	4.54	6.68	6.58
Total	100.91	100.34	100.08	100.27	100.52	101.88
Cations for 12 oxygens						
Si	3.04	3.28	3.26	3.28	3.02	2.99
Al	1.96	2.16	2.14	2.16	2.00	2.01
Fe	1.55	2.08	1.88	2.31	1.93	2.08
Mn	0.60	0.36	0.35	0.17	0.30	0.14
Mg	0.14	0.24	0.18	0.30	0.18	0.24
Ca	0.66	0.50	0.83	0.42	0.57	0.55
Total	7.96	8.63	8.65	8.63	7.98	8.00
Almandine(%)	52	65	58	72	65	69
Spessartine(%)	20	11	11	5	6	8
Pyrope (%)	5	8	6	9	10	23
Grossular(%)	22	16	25	13	19	18

Fe0* means Fe0+Fe2O3

Table 3: Compositional data of garnets from the Arun Valley

	Higher Himalaya		MCT zone					
Sample No	451	451	532	532	530	530	524	524
Analysed Position	Core	Rim	Core	Rim	Core	Rim	Core	Rim
SiO2	38.43	38.49	37.79	37.59	38.34	38.30	37.97	38.00
Al2O3	21.26	21.33	21.03	21.23	21.64	21.60	21.41	21.50
FeO*	36.04	34.14	28.89	35.26	34.58	34.30	31.67	32.98
MnO	1.71	1.54	6.83	2.12	0.13	0.22	3.42	2.25
MgO	3.07	2.59	0.92	1.38	3.51	3.70	1.82	2.15
CaO	1.19	3.50	6.06	3.71	3.85	3.16	5.44	4.73
Total	102.22	101.59	101.70	101.34	102.08	101.33	101.83	101.63
Cations for 12 oxygens								
Si	3.03	3.04	3.01	3.00	3.00	3.01	3.00	3.00
Al	1.97	1.98	1.97	2.00	2.00	2.00	1.99	2.00
Fe*	2.37	2.25	1.92	2.36	2.26	2.26	2.09	2.18
Mn	0.11	0.10	0.46	0.14	0.01	0.01	0.23	0.15
Mg	0.36	0.30	0.11	0.16	0.41	0.43	0.21	0.25
Ca	0.10	0.30	0.52	0.32	0.32	0.27	0.46	0.40
Total	8.03	7.97	8.00	7.99	8.00	7.99	8.01	7.99
Almandine (%)	81	76	64	79	75	76	70	73
Spessartine (%)	4	3	15	5	0	0	8	5
Pyrope (%)	12	10	4	6	14	15	7	8
Grossular (%)	3	10	17	11	11	9	15	13

FeO* total FeO+Fe2O3

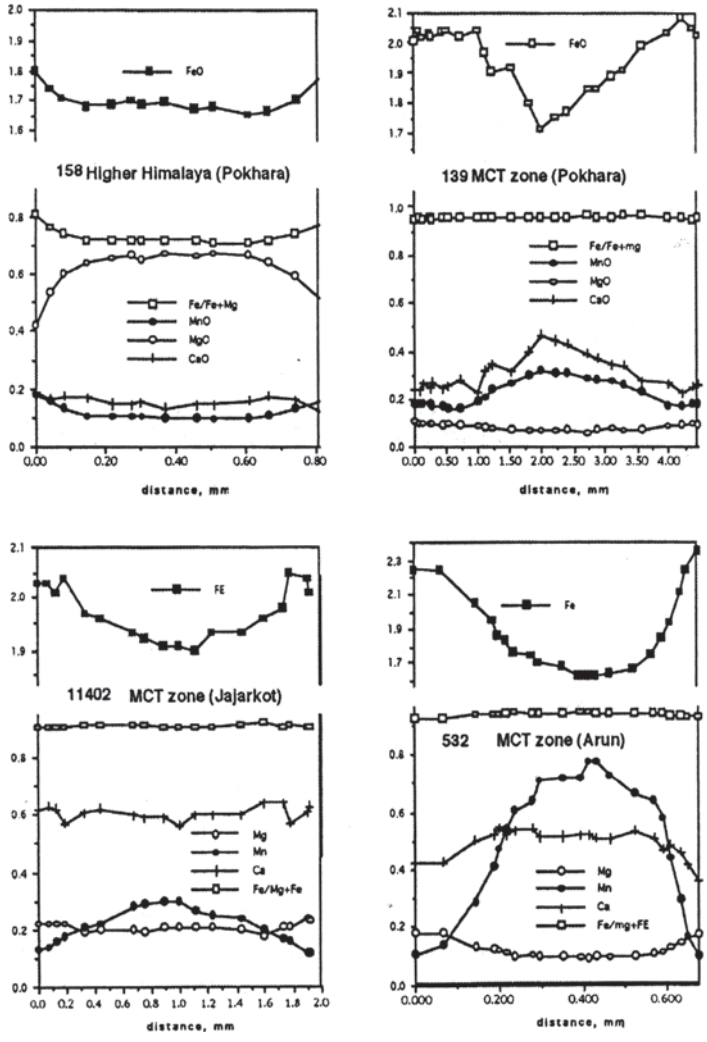

Fig. 4: Compositional profiles of garnet. (a) Higher Himalaya of the Pokhara area, (b) MCT zone of the Pokhara area, (c) MCT zone of the Jajarkot area and (d) MCT zone of the Arun Valley

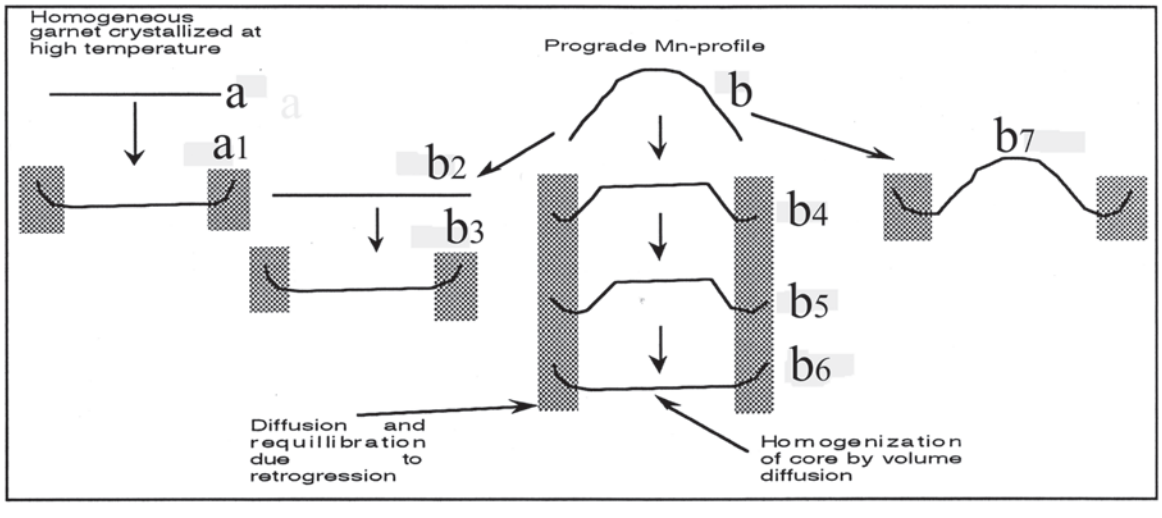

Fig. 5: Schematic diagram showing the possible evolution of garnet compositional profiles in the study area

like in Fig. 4a may be produced by two ways, e.g., retrogression of initially homogeneous garnet (Fig. 5a1) and homogenization of growth profile along with retrogression at the rim (Figs. 5b3 and 5b6) (Spear 1993). Presence of relict growth zoning indicates that the Higher Himalayan garnets initially had bell-shaped Mn-profiles. The bell-shaped profiles were modified by subsequent volume diffusion in the cores and diffusion and re-equilibration due to retrogression at the rims as in Fig. 16b6. Incomplete homogenization of the cores and weak retrogression at the rims (as in Fig. 16b5) may have produced the zoning patterns like in the Fig. 4(a).

The garnet compositions demonstrate a sharp difference in grade and history of metamorphism between the MCT zone and the Higher Himalaya. Garnets from the Higher Himalaya are rich in Fe-Mg contents while those from the MCT zone are rich in Fe-Mn contents. It shows that the Higher Himalayan rocks are higher in grade than those of the MCT zone.

Garnets from the Higher Himalaya have experienced strong retrograde metamorphism as shown by the compositional profiles. Most of the cores have been homogenized by later diffusion. On the other hand, the garnets from the MCT zone show only growth zoning with a little or no retrograde re-equilibration at the rims. It indicates a sharp metamorphic discontinuity across the Upper MCT. Most probably, the Higher Himalaya experienced kyanite-grade prograde metamorphism before thrusting along the Upper MCT. This metamorphic event is known as the Eohimalayan metamorphism (Arita et al. 1990). Garnets with growth zoning in the MCT zone were formed during the Neohimalayan metamorphism at the time of Upper MCT movement. Post-metamorphic thrusting along the Upper MCT resulted in the retrogression of garnet rims.

Similarly, garnet compositional similarity between the Jajarkot Klippe (Fig. 3) and the MCT zone rocks indicates that the Lesser Himalayan klippes most probably roots to the MCT zone as suggested by Arita et al. (1982). Similar studies in other parts of the Nepal Himalaya may solve the root zone controversy of the Lesser Himalayan crystalline nappes.

CONCLUSIONS

The Higher Himalaya, Main Central Thrust zone and the Lesser Himalayan crystalline nappes comprise pelitic and psammitic schists and gneisses with abundant garnet porphyroblasts. Porphyroblasts from the Higher Himalaya are pre-kinematic and have inclusion-rich cores and inclusion free rims. Porphyroblasts from the MCT zone and Lesser Himalayan crystalline nappe with “snow-ball” texture are syn-kinematic.

Compositional analysis of the garnet porphyroblasts shows that garnets from the Higher Himalaya are relatively Mg-rich (Mn-poor) and characterized by a flat compositional plateau at the cores and steep retrograde rims. Garnets from the MCT zone are relatively Mn-rich compared to that of the Higher Himalayan garnets. They are also zoned with Mn-poor (Fe-rich) cores and Mn-rich (Fe-poor) rims. They show bell-shaped profiles, with Fe gradually increasing and Mn decreasing towards the rims, typical of prograde growth zoning. However, the profiles are reversed at the margin due to late-stage retrogression.

The garnet microstructure and composition show a contrasting metamorphic evolution of the Higher Himalaya and the MCT zone in Nepal. Garnet compositional similarity between the Jajarkot Klippe and the MCT zone rocks indicates that the Lesser Himalayan klippe most probably roots to the MCT zone.

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Arsenic in groundwater of Terai region of Nepal: Possible geological sources and health impacts

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ABSTRACT

Arsenic is one of the oldest poisons known to mankind. It is widely distributed throughout the Earth's crust and is introduced into water through the dissolution of minerals and ores rich in arsenic. It is found in more than 150 arsenic bearing minerals. Elevated concentration of arsenic has been recorded from sulphide ore and other arsenic containing minerals. Arsenic in the sediments could be derived from two processes; (a) as the denuded, fragmented, weathered and eroded particles of parent arsenic-bearing minerals and rocks from the source regions, and (b) as adsorption of arsenic in the sediment grains and coating from arsenic rich aqueous solution. There are several arsenic contaminated shallow wells almost in all districts of entire Terai. The uneven distribution of concentration of arsenic in groundwater might be related to different sub-surface geological conditions of the Terai plain. It is an extremely toxic, not visible in water, no taste and no smell. Therefore, it is necessary to analyze the aquifer materials at different depth such that we can assess the position of arsenic contaminated and safe aquifers. This assists us to avoid the polluted aquifers during the development of drinking water. Health problems related to arsenic are already visible in some villages of Terai districts of Nepal. Both keratosis and melanosis problems are reported in the community of Terai, however, health workers and local community know very little about the impacts of arsenic.

Keywords: Arsenic, groundwater, aquifers, health impact, Terai of Nepal

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INTRODUCTION

Arsenic contamination in groundwater has been recognized as a great threat to water supply and public health in many countries in the world. Bangaladesh and West Bengal, India are still struggling to provide arsenic-safe water to concerned people exposed to high level of arsenic from drinking water. Arsenic poisoning in groundwater of Terai is also an emerging issue for Nepal. It is an extremely toxic, not visible in water, no taste and no smell.

There exists a large debate on the source and release mechanism of arsenic in groundwater. But now, it is widely accepted to be geological sources of arsenic in water. Several geological (lithological, mineralogical, geochemical, and hydrogeological) studies are necessary to understand the source and release mechanism of arsenic in groundwater of Terai.

It has been identified a cause of cancer due to arsenic by the International Agency for Research on Cancer (IARC). The World Health Organization (WHO) has fixed a provisional guideline values (0.01 mg/l) for maximum concentration of arsenic in drinking water tolerable to human health (WHO 1993). It has been found that inorganic arsenic is more toxic than organic and within the inorganic form, the trivalent (arsenite, As^{+3}) is more toxic than pentavalent (arsenates, As^{+5}). It is reported that arsenite is the major water soluble species in groundwater. The most commonly reported symptoms of chronic arsenic exposure are hyper pigmentation, depigmentation, keratosis and peripheral vascular disorders, skin cancer and a number of internal cancers. The patient shows inability to walk, debilitating pain and watery eyes. The Terai community of Nepal is also suffering from the diseases induced by the use of arsenic contaminated water. Both keratosis and melanosis are found in the local people who have been using arsenic contaminated water for long time.

SOURCES AND MOBILIZATION OF ARSENIC

Arsenic is widely distributed throughout the Earth's crust. It is found in more than 150 arsenic bearing minerals. The most common pure arsenic ore is realgar (AsS). Some other common arsenic minerals may be listed as: arsenopyrite (FeAsS), arsenolite (As_2O_3), enargite (As_5S_4), nickel glance (NiAsS), orpiment (As_2S_3), apatite [$Ca(PO_4)_2$ F], etc. High concentration of arsenic has also been recorded in pyrite, magnetite, ultrabasic rocks, shales/slates, phosphorites, coals and hot springs (Anonymous 1969).

The primary sources of arsenic are the natural rocks, minerals and ores rich in arsenic. It is introduced into the atmosphere, hydrosphere and biosphere from primary sources of different physical, chemical and biological

agents. Arsenic can be released by the weathering of arsenic rich rocks and minerals into waters, solids and sediments. Gaseous form of arsenic returned back to land and water by rains and atmosphere fall-out (Fig. 1).

The genesis of arsenic minerals begins at the bottom of lakes and oceans, collecting from all possible sources, from biological and anthropogenic sources, from crustal weathering, from deeper origins through hot springs and geothermal systems (from active ocean ridges and diverging zone of linear fracture for upwelling of magma) and through the leaching of basalts (basic extrusive rocks). Arsenic minerals occur in hydrothermal veins, in sulfide veins, in calcareous shales and marbles in close proximity to a dyke of basic intrusive rocks. Arsenic in the sediments could be derived from two processes: (a) as the denuded, fragmented, weathered and eroded particles of parent arsenic-bearing minerals from the source regions, and (b) as adsorption of arsenic in the sediment grains and coating from arsenic rich aqueous solution. Acid Mine Drainage (AMD) from largely coal and to some extent gold mining often contains large concentrations of both iron and arsenic due to oxidation of pyrite.

The mechanism of release of arsenic from geological sources into the groundwater is still debatable. Researchers have their own ideas on the ways that arsenic enters into the groundwater. Basically, there are two main working concepts on mobilization of arsenic from natural sources to groundwater: Pyrite oxidation and Qxy-hydroxide reduction.

Pyrite oxidation concept is based on the assumption that arsenic is present in the sulphide minerals (pyrite, arsenopyrite, etc). Lowering of the water table due to pumping introduces oxygen, which causes the breakdown of the sulphide minerals releasing arsenic. According to ***oxy-hydroxide reduction concept,*** arsenic weathered from hard rocks/minerals is carried away as suspended load of the rivers adsorbed onto iron oxides or hydroxides. Following deposition of this fine sediment, decomposition of organic matter leads to strong reducing condition which causes dissolution of the iron or hydroxides and consequently releases arsenic into solution.

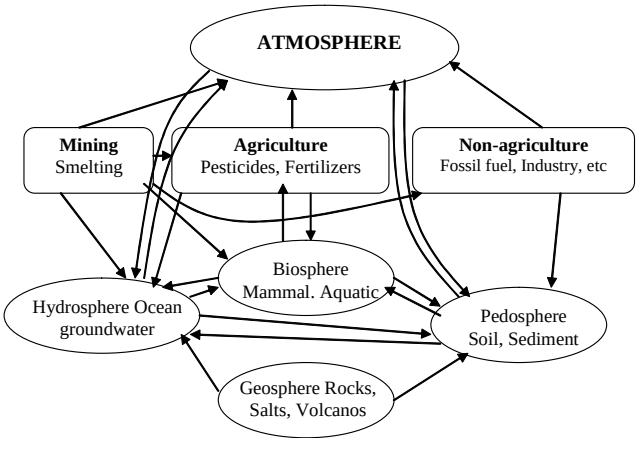

Fig. 1: The environmental cycle of arsenic (after Bhumbla and Keefer 1994)

SOURCES OF ARSENIC IN NEPAL

At present, there exist several possible natural sources of arsenic in Nepal. On the basis of chemical and mineralogical analysis of collected rock, mineral, soil and water samples from different parts of Nepal, several primary sources of arsenic have been identified (UN publication 1993; Sharma 1999; Sah et al. 2003; Paudyal 2005). The sulphide minerals from the polymetallic deposit of Ganesh Himal, iron ore of Phulchauki area, ferruginous concretions of Tertiary deposits, bituminous coal of Tosh area, Dang; Kalimati clay of the Kathmandu Valley and sediments from hot spring water show high values of arsenic concentrations. Ferruginous quartzite, sandstone and mudstone also show comparatively higher values of arsenic. Certainly, these above mentioned minerals, rocks and sediments represent the primary sources of arsenic in Nepal. Ultimately all these earth materials reach to the Terai plain of Nepal. The provenance of present aquifers of Terai is the Siwaliks and its northern parts.

The Terai plain of Nepal consists of lose sediments ranging from clay to big boulders derived from Siwaliks and its northern elevations by rivers and glaciers. These clastic sediments may contain arsenic rich minerals and rock fragments. After the dissolution of arsenic minerals, it ultimately mixes with the groundwater. Arsenic either comes from directly from aquifer materials or it enters due to infiltration of surface water rich in arsenic through river beds or permeable soils. This explanation is also supported by the study of Emerman et al. (2010) in the Sun Koshi and Sapta Koshi Rivers that arsenic contamination of groundwater upstream of the Terai region results from recharge by losing streams with elevated arsenic while arsenic contamination in the Terai plain results from transfer of arsenic from sediments to groundwater.

The uneven distribution of concentration of arsenic in groundwater might be related to different sub-surface geological conditions of the Terai plain. The lithological features and mineralogical composition of the aquifer material varies laterally as well as vertically during the time of deposition. Different depositional environments like alluvial fan, ox-bow lake, river channels, flood plains, point bars, crevasse-splay deposits, river basin deposits etc. can be recognized within the sedimentary succession of the Terai plain. Source materials and their distribution control the concentration level of the arsenic in the area. Therefore, it is necessary to analyze the aquifer materials at different depth such that we can assess the position of arsenic contaminated and safe aquifers. This assists us to avoid the polluted aquifers during the development of drinking water.

ARSENIC IN TERAI DISTRICTS

There are several arsenic contaminated shallow wells almost in all districts of entire Terai of Nepal. According to National Arsenic Steering Committee (NASC 2005) and Environment and Public Health Organization (ENPHO) (2003), nearly 23% of the wells exceed the WHO standard (10 ppb) and 8% exceeded the Interim Nepal Standard (50 ppb). An estimate of the number of people in the Terai region who may be using groundwater containing 'high' arsenic concentration, is about 3.2 million, 29% of Terai population. The percentage of wells contaminated above 50 ppb varies at district level from 0% in Dang, Chitawan, and Sunsari to 25.7% in Nawalparasi. The highest concentration of arsenic (upto 2,620 ppb) was measured in Devdaha VDC of Rupandehi district. The NASC is also upgrading the data on arsenic testing each year. The result of arsenic blanket testing (NASC 2005) of highly affected districts is shown in Table 1.

HEALTH IMPACTS

Clinical studies show that about half the arsenic ingested by individual is excreted, while the other half accumulates in the body. Arsenicosis is a chronic health condition arising from prolonged ingestion (more than 6 months) of arsenic above safe dose, usually manifested by characteristic skin lesions, with or without involvement of internal organs. Effects range from acute lethality to chronic impacts, such as cancer and diseases of the vascular system. The effects are also reported in respiratory, cardiovascular, immune, genitourinary, reproductive, gastro-intestinal and nervous systems.

Health problems related to arsenic are already visible in some villages of Terai districts of Nepal. The most affected six districts of Terai are: Nawalparasi, Parsa, Bara, Rautahat, Rupandehi, and Kapilbastu (DWSS/UNICEF 2002; Sah et al. 2003; RWSSSP 2003, 2004; Maharjan 2004; Maharjan and Shrestha 2005; Adhikary 2005; Paudyal 2006; Adhikari 2006; Pandit and Paudyal 2011). The cases of arsenicosis are also commonly reported from other remaining fourteen districts of Terai. The effects are reported higher in the older age groups. The surveys also showed higher arsenicosis for males compared to females. The symptoms of arsenicosis are also very difficult to differentiate from other clinical conditions. In Nepal, the detection and management of arsenicosis is still in beginning stage. There exists no uniform, accepted protocol for detection and management of arsenicosis cases. The present day survey shows the presence of both keratosis and melanosis affects the community of Terai people.

Table 1: The most arsenic affected districts of Nepal (Source: NASC 2005)

S. N.	District	Total No. of Test	Population using arsenic tested tube wells			
			< 10 ppb	10 to 50 ppb	> 50 ppb	Max. Concent. Detected
1	Kanchanpur	33507	30554	2441	512	450
2	Kailali	14567	12414	2097	56	213
3	Bardiya	824	651	147	26	181
4	Banke	4605	3723	828	54	270
5	Kapilbastu	39915	26060	2662	1193	589
6	Rupendehi	2958	2433	401	124	2620
7	Nawalparasi	31655	23480	4347	3828	1200
8	Parsa	28385	26033	1587	765	456
9	Bara	39837	35066	3147	1487	254
10	Rautahat	50086	39629	9319	1138	500
11	Sarlahi	50543	43205	67482	590	98
12	Mahottari	1202	1088	104	10	80
13	Dhanusha	44947	42981	1803	163	140
14	Siraha	45902	38555	6020	1327	250
15	Saptari	56720	53523	2608	589	98
16	Morang	936	531	385	20	70

In Nepal, some governmental and non-governmental organizations are conducting short-term mitigation programs in affected districts and introducing various kinds of household arsenic removal filters like, two gagri filters, three gagri filters, improved bio-sand filters and arsenic-iron removal plants, rehabilitation of dug wells and arsenic safe tube wells. Realizing the need for knowledge sharing and management of arsenic, the Environment and Public Health Organization and the Nepal Red Cross (NRC) established Arsenic Information Centers (AIC) in major arsenic affected districts of Nepal. AIC are equipped with arsenic field test kits, and capacity for assembling and providing various arsenic removal filters. But the sludge coming out of these filters is highly toxic and contaminating surrounding micro-environments: soils, agricultural raw foods, surface water bodies, atmosphere and others. As there is no known specific treatment for arsenicosis, the first and best way is to stop consumption of arsenic contaminated water. So, efforts need to be concentrate on development of arsenic safe water sources. Study shows that the most of the health workers and community people know very little about the health impacts of arsenic poisoning. Therefore, awareness raising programs and standard Information, Education and Communication (IEC) materials are very essential to the local communities and health workers for detection and surveillance of arsenicosis cases.

CONCLUSIONS

The primary sources of arsenic are the natural rocks and minerals rich in arsenic. Arsenic is introduced into the atmosphere, hydrosphere and biosphere from the primary sources by different physical, chemical and biological agents. Weathering of arsenic rich rocks and minerals releases arsenic into waters, soils and sediments. Gaseous form of arsenic returns back to land and water by rains and atmosphere fall-out. Aquifer sediments of Terai plain have been found to contain ferruginous concretions and coating rich in arsenic. Under suitable physio-chemical conditions, the precipitated ferruginous coatings and concretions get dissolved or adsorbed releasing arsenic together with iron in groundwater.

The sporadic and spotty distribution of arsenic poisoning in the groundwater is possibly related to different sub-surface geological conditions existing in the Terai plain. Systematic study on the mineralogy and geochemistry of the aquifer sediments indicates the arsenic-polluted and safe aquifer distribution in the area. It may help to select the arsenic free aquifer for the development of drinking water wells.

Arsenic contamination in groundwater of Terai plain of Nepal has been recognized and documented as emerging health problem. The problem of arsenicosis has been observed in several villages of the Terai districts even with very little health survey. Both keratosis and melanosis problems are reported in the community of Terai. Most of the health workers and community people do not know about the health impacts of arsenic poisoning.

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Groundwater utilization in Dang District, western Nepal and conjunctive use of water resources

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ABSTRACT

Dang and Deaukhuri valleys of Dang District are very fertile for agricultural productions. The local streams of Dang Valley are full of water during Monsoon period but there is no perennial surface water resource for year round irrigation. The perennial Rapti River passes through the middle part of the Deaukhari Valley. But, only about one third area of the valley is irrigated so far. Both valleys are potential for groundwater, although Dang Valley is poor in groundwater potentials compared to the Deaukhari Valley because of the nature of sediments. But groundwater can be exploited by developing proper technology and year round irrigation can be provided by conjunctive use of groundwater and surface water resources.

Keywords: Groundwater reservoir, shallow and deep tube wells, groundwater irrigation system, Dang and Deaukhari valleys, western Nepal

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INTRODUCTION

The Indo-Gangetic plain is one of the greatest groundwater reservoirs in the world. Terai of Nepal is also one of the part of that plain and it is hydrologically connected. Loose and very thick unconsolidated sediments of alluvial nature of Terai are approprite aquifers for groundwater. And it is our fortunate that there is fresh water in every step. The groundwater can be exploited by developing appropriate technology wherever and whenever needed.

There is about 12000 MCm of renewable groundwater reserve in Terai of Nepal. It can irrigate more than 1221000 ha. of land. The cheapest technology of irrigation, the shallow tube wells only can irrigate more than 726000 ha.

GROUNDWATER FEASIBILITY

Dang District consists of two big tectonic valleys: Dang and Deaukhuri. The elevation of Dang Valley and Deaukhari Valleys are about 650 m and 225 m from msl, respectively. Cultivable land of the district is 69950 ha. Only about 38% of cultivable land has got irrigation facility so far.

Since the establishment of Groundwater Office in this district in 2040/041, investigation, studies and monitoring of groundwater resources had been carried out its regular works. It is found that more than 100 m thick unconsolidated formation basin areas of both valleys are giving raise groundwater reservoirs. Various investigation works of groundwater resources made so far, it is found:

Total Groundwater Feasible Area – 28350 Ha.

Shallow Tube Well (STW) Feasible Area – 5400 Ha.
- Dang Valley– 2250 Ha.
- Deuakhuri Valley– 3150 Ha.

Deep Tube Well (DTW)Feasible Area – 22950 Ha.
- Dang Valley– 15000 Ha.
- Deuakhuri Valley– 7950 Ha.

Some areas like Dharna, Tarigaun, and some parts of Duruwa, Goltakuri and Urahari VDCs of Dang Valley are very good potential area for groundwater. The discharge of the groundwater ranges from 30 to 40 l/s in deep tube wells and from 5 to10 l/s in shallow tube wells. In these areas 26 units of deep tube well and 210 units of shallow tube well irrigation systems are already developed providing irrigation facility to about 1565 ha. of land. Other areas are comparatively poor in groundwater potential source. Shallow tube wells are almost not feasible. Discharge range in deep tube wells is 10-15 l/s. 9 units of such deep tube well irrigation systems are developed in different places covering 155 ha. Hence, there is no alternative perennial water resource for year round irrigation in Dang Valley; the only alternative has been development of groundwater

Table 1: Groundwater irrigation systems developed in Dang District

TW Type	Total Nos.	CA Ha.	VDCs Covered	House Holds	Population
DTW	53	1785	12	3250	36030
STW	1418	4079	11	10588	46307
	1471	5864	23	13838	82337

resources. As Dang Valley is a tectonic valley, the nature of groundwater reservoir is quite different from the Terai. Although the yield in Dang Valley is comparatively poor as compared to Terai and is not equal in all places, and it should be considered as natural gift. The challenge is the development of proper technology conservation and utilization of groundwater resources in such areas. In this valley there are so many seasonal streams, they consist penalty of water during rainy season. This water can be reserved in surface reservoirs, recharged to groundwater reservoirs and used for irrigation till February to March (dry season). Thus year round irrigation can be provided by conjunctive use managing small water resources.

Aquifers of Deaukhuri Valley are quite different. These aquifers are made of alluvial deposits which are coarse, loose and full of water giving rise very good aquifers. The perennial Rapti River flows intersecting Deaukhuri Valley into two parts. This river has a very good role for regular recharging these aquifers. Thus the valley has a very good groundwater reservoir. The discharge range of deep tube wells varies from 40 to 45 l/s and from 10 to 20 l/s in shallow tube wells. 18 units of deep tube well irrigation systems and 1158 units of shallow tube well irrigation systems are developed providing year round irrigation facility for about 3600 ha. of land. 1471 tube wells (deep and shallow) groundwater irrigation systems have well developed in Dang District (Table 1).

The command area of proposed "Badkapath Irrigation Project" lies towards the left bank of Rapti River. It provides irrigation to Gorbadiha, Gangaparaspur and Gadhawa VDCs and covers 4000 ha. The estimated cost is 1.75 billion rupees in cash. In addition to this amount, the nature will loose 618 big trees including 300 nos. of big Sal trees. The total cost will be still higher, although by the view point environmental effects it can not be evaluated in terms of money. Some areas such as Malmala, Badahara and Jethangaon and Baghmaruwa are still left.

Gorbadiha, Gangaparaspur and Gadhawa VDCs are also very good potential area for groundwater as well. About 40% (1600 ha.) is feasible for shallow tube wells and about 60% (2400 ha.) is feasible for deep tube wells. More than 550 shallow tube wells and 4 units of deep tube well irrigation systems are already developed providing irrigation to 1250 ha. of land. Out of 1600 ha of shallow tube well feasible area it needs 200 nos. of more shallow tube wells which may cost about 10 millions rupees. Construction of shallow tube wells in this area is going on every year as per farmers' demand by APP special program and privet sector as well. It will not take more time to cover shallow tube well feasible area without any extra effort.

CONJUNCTIVE USE OF WATER RESOURCES

It is a process of recharging of groundwater as natural reservoir during peak runoff and smallest demand period and its utilization during low runoff and high demand. During Monsoon period there is very high runoff of water in Rapti River and water is spread every where within the valley and low demand of water. During dry season there is very high demand of water in Rapti Basin including to India. This low supply and high demand of water in dry season and high supply with low demand of water in Monsoon including supply to surface water deficit area can be managed by conjunctive use. In Dang Valley also, although there is very less perennial surface water resource, on the basis of total annual volume there is penalty of water. There is heavy runoff in every stream during Monsoon. By the basin management and conjunctive all water resources available in the basin it can be fulfilled all demands of water.

Out of 2400 ha. of deep tube well feasible area, it needs about 60 of deep tube well irrigation systems which may cost about 330 millions rupees. Including to the cost of additional shallow tube wells, the total cost may be about 340 millions rupees to provide irrigation facility to the proposed command area of Badkapath as well the areas left by this project. The cash investment will be comparatively very low. It will not need destruction of even a single tree of forest. There will be no water right problem, no environmental problem and very big and complicated structures. Addition of irrigated area will start from very beginning and it can be completed within five or six years. The aquifers are within the depth of 100 m. They are made of coarse unconsolidated materials regularly recharging by Rapti River, so that there will be no problem regarding to

the groundwater reservoir even in the future. Although each system has got its own technical significance and every thing should not be compared only in terms of money, but is it justice to leave some areas without irrigation only because of not being feasible for surface water? It is the duty of state to provide irrigation facility developing available resources and technology. So the planning should be focused to provide irrigation facility to the whole area by any resource, not to develop system for particular resource only. If some deep tube wells could be included in this project the whole area would be irrigated.

More areas in Deaukhuri Valley are still left without irrigation facility. Two more VDCs (Bela and Rajpur) are having plain and very fertile land but depending only upon rain. Some parts of these VDCs may be feasible for surface water irrigation, some parts are feasible for shallow tube wells and some parts are feasible for deep tube wells. It is the responsibility of state to develop infrastructures. Farmers need irrigation for agriculture purpose; they do not matter about the type source. So it will not be fair to leave these areas un-irrigated, because of not feasible only for surface water resources. By conjunctive use of water resources available in these VDCs it is possible to irrigate the whole area. This is the sprit of present irrigation policy as well.

Not only in Badkapath area there may be some areas left in Sikta irrigation, Bagmati and may be in other irrigation projects as well. Every one knows that, areas which do not lie within the contour of canal system can not be irrigated whether that may be within the command area. It is also not possible to provide water equally in head and tail ends, especially during dry period it becomes almost impossible, that's why there is big demand of shallow tube wells in tail ends of Rajapur Irrigation Project. And several shallow tube wells are already constructed. Although the source of this project is snow fed river and there is no problem regarding to the source round the year.

From Chandra Nahar, since the 87 years' history of irrigation development in Nepal so many projects like ILC, ISP, NISP, SISP, IWRMP, Major projects, Large projects, Medium projects, Small projects and many more are implemented. Almost all locally available surface water resources are already tapped during this period except some exceptional cases. In some cases same source is used several times, such as west Rapti is used for Paraganna, Sikta and still to be used for Badkapath in Nepal including very old system of Laxmanpur barrage in cross boarder. Every thing has got some limitation, and in it is not always possible to increase irrigated area depending only upon the locally available surface water resources. Irrigation is not only the deviation surface flow from one place to another place. It is the development and management of water resources available in the area for artificial watering of land in equal proportion up to the root zone to sustain plant growth and its regular monitoring. It also includes conservation of water resources as well. India spends about 70 corer Indian rupees per year for plantation in the catchments area of Bhakhada dam so that the sediments could retain the water in the form of groundwater reservoir and discharge in the form of springs to recharge the river regularly round the year.

Trans-basin water transfer is long term program. There may be so many problems like political, social, environmental, financial, and sometimes bilateral as well to be solved. Construction work itself takes long time. Still the problem of equally distribution of water in head and tail ends and whenever farmers need, will remain unsolved.

The development of groundwater irrigation system has got always equal importance even after the fully development of surface water resources including trans-basin water transfer. Groundwater irrigation system is a supplementary system to assure year round irrigation. So its development should also be given equal importance and it should never be considered as alternative system.

Ministry of Irrigation is a multi-disciplinary organization. There is no problem for experts regarding to the development, utilization and management of groundwater and surface water resources or conjunctive use. The present need is to provide equal opportunity, exposure and importance to all disciplines and the vision of equal importance for all natural resources, different technologies and commitment.

The present irrigation policy should give the special emphases to:

- Promotion of conjunctive use of groundwater and surface water irrigation systems along with the initiation of new and non-conventional irrigation systems such as rain water harvesting, pond, sprinkler, drip, paddle pumps and other irrigation systems
- Development of storage type irrigation systems for making round the year irrigation to encounter the problem of low flow of rivers in the winter season
- Promotion, conservation and development of water reservoirs, rain water harvests and groundwater resources
- Trans-basin water transfer and management from water-surplus large river basins to the water deficit area

Only alternative to increase irrigated area in very short time is conjunctive use of groundwater and surface water resources. Water can be provided equally in all parts whenever needed. It is also the mandate of present irrigation policy. Now it is the responsibility of officials, water resources experts and irrigation professionals to implement the policy practically.

CONCLUSIONS

The cultivable area of Dang District is about 70000 ha. and only 38% is irrigated so far. There are no perennial surface water resources in Dang Valley but there is penalty of water in local streams during Monsoon. The Rapti River passes through Deaukhuri Valley playing a very good role for regular recharging the aquifers. Some irrigation systems are developed but more than two third areas are still left. Groundwater potential resources are available in both valleys and so many deep and shallow tube wells are developed to provide year round irrigation to about 6000 ha. By basin management and conjunctive use of available water resources year round irrigation can be provided to additional areas in short period and it is comparatively low cost than the surface system. During the 87 year's history of irrigation development in Nepal almost all locally available surface water resources are already developed so far. Trans-basin water transfer is long term program. Now it is the time to develop groundwater resources and to increase irrigated area by conjunctive use. Irrigation policy has given equal importance for the development of all water resources, technologies and conjunctive use. Now it is the time of real practice.

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Hot springs in Nepal

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ABSTRACT

Hot spring is a natural source of hot water that is mainly located near thrust faults where rain or surface water penetrates into the depths of the earth, gets heated by the high temperature and ultimately rises again to the surface through the fissures or the exposures of rocks in the form of hot springs (thermal springs). In the Nepal Himalaya, the hot springs correspond to the exit points of meteoric water which is recharged on the High Himalaya (Higher Himalaya and Tibetan-Tethys Himalaya) and Tibetan plateau and the geothermal circulation meet high temperature at great depth and it is drained out along the Main Central Thrust (MCT) zone to the surface. In the context of Nepal, the hot springs are mainly located around the Main Central Thrust zone and few in the Siwalik hills near to the Main Boundary Thrust. Hot springs provide natural relaxation and medicinal importance in Nepal.

Keywords: Hot springs, thrust faults, meteoric water, natural relaxation and medicinal importance

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INTRODUCTION

Hot spring is a natural source of hot water that is mainly located near thrust faults where rain or surface water penetrates into the depths of the earth, gets heated by the high temperature and ultimately rises again to the surface through the fissures or the exposures of rocks in the form of hot springs (thermal springs). These are formed by ground water which becomes heated by contact with hot rocks or steam of magmatic origin and the heated water comes out on the surface through the veins or fissures as spring. No universally accepted definition of the hot spring is found. It can be defined in different ways such as any geothermal spring, or a spring with water temperature found above its surroundings, or a natural spring with water temperature above body temperature-normally between 36.5 and 37.5 ^{0}C (98 and 100^0 F), or a natural spring with warm water above body temperature. There are also other sources to produce thermal springs (Sterns et al. 1937), they are magmatic sources, radioactive disintegration, thermal gradient and chemical changes. Hot springs are mostly found in volcanoes and in the area of young tectonic belts. Mineralization of the springs depends on the chemical composition of the rocks through which it penetrates.

In the context of Nepal, the hot springs are mainly located around the Main Central Thrust zone and few in the Siwalik hills near to the Main Boundary Thrust (Amataya 2006).

People for healing and health related cares are using the hot water since long time. Hot springs provide natural relaxation and medicinal importance in Nepal. The tourists also like to take bath by hot springs during their trekking in the hilly region.

The geologists can identify more hot springs during their geological survey. There are still many unidentified and isolated hot springs. Geologically, the hot springs are located near to thrusts (particularly Main Central Thrust and Main Boundary Thrust), which can be easily identified and located. These springs have religious and medical importance for Nepalese people. Bathing by hot springs is recommended for treatment of rheumatism, gout and skin diseases. Tourists take bath to get relief from tiredness of their long trekking in the mountain.

ORIGIN OF HOT SPRING IN NEPAL HIMALAYA

In the Nepal Himalaya, the origin of the hot spring is not well recognized. However, few researches on hot springs and their origins were carried out (Dixit 1977; Cettin et al. 2001; Perrier et al. 2002; IRDS 2003; Jnawali 2004; Alam and Chandrasekharam 2004; Kandel 2007; Girault et al. 2009). The origin of the hot springs is mainly related to the movement of thrust faults (Main Central Thrust and Main Boundary Thrust). According to Perrier et al. (2002) the hot springs correspond to the exit points of meteoric water which is recharged on the High Himalaya (Higher Himalaya and Tibetan-Tethys Himalaya) and Tibetan plateau (Fig. 1). Cattin et al. (2001) explain that the geothermal circulation meet high temperature at great depth and it is drained out along the Main Central Thrust (MCT) zone to the surface. The MCT, at present, is not considered as an active fault

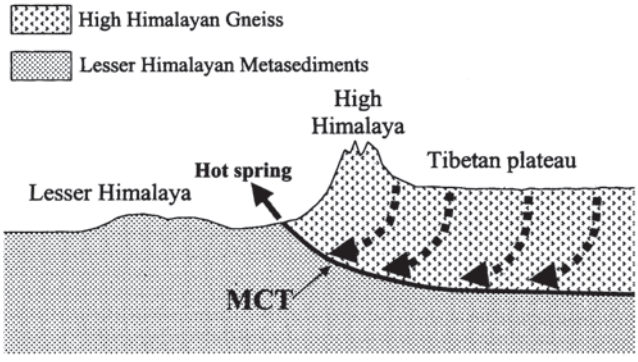

Fig. 1: Schematic diagram for geothermal circulation in Nepal Himalaya. Hot springs are originated by recharging meteoric water in the High Himalaya (Higher Himalaya and Tibetan-Tethys Himalaya) and Tibetan plateau. The recharged meteoric water drains out along the Main Central Thrust (MCT) or around the MCT zone to the surface.

(Upreti 1999, Pandey et al. 1999), however, the MCT zone corresponds to a major zone of increased permeability in the brittle crust (Perrier et al. 2002). In some area the MCT zone is reactivated and late brittle faults have been formed. The reactivation age ranges from 6 Ma to 4 Ma dated by $^{40}Ar/^{39}Ar$ dating of biotite and muscovite. The young brittle faults are mapped in the Syabrubensi of Langtang area (Macfarlane et al. 1992). Similarly, the young deformation events have been studied by Copeland et al. (1991) along the Burhi Gandaki Valley and Ankhu Khola, Macfarlane (1993) along the Langtang Valley, central Nepal and Edwards (1995) along the Marsyangdi Valley, western Nepal and the timing of young deformation events range from late Miocene to early Pliocene along and around the MCT zone. Copeland et al. (1991) suggest that hydrothermal fluids produced in the MBT should be percolated at the MCT zone with late phase of heating around 4 Ma to 5 Ma. Macfarlane (1993) suggests the late phase deformation around the MCT

Table 1: Locations of hot springs, their flow rates and temperatures in Nepal (Compiled by Kandel 2007)

S.N.	Locality	Longitude (E)	Latitude (N)	Flow rate (1/s)	Surface temperature (^{0}C)
1	Sribagar, Darchula	80.60^0	29.90^0	0.85	57-73
2	Sina-Tatonpani, Darchula	80.70^0	29.90^0	0.76	warm
3	Chamaliya, Darchula	80.60^0	29.70^0	0.25	warm
4	Tapoban, Bajhang	81.20^0	29.60^0	0.2	warm
5	Dhanchauri-Luma, Jumla	82.30^0	29.30^0	0.6	24
6	Tilandi, Jumla	82.10^0	29.20^0	36-42	110.6
7	Rior, Dang	82.70^0	27.90^0	1.5	33
8	Suraikhola, Kapilvastu	83.30^0	27.80^0	3.7	50.1
9	Chaarang, Mustang	83.98^0	29.20^0	0.2	33
10	Dhi, Mustang	83.98^0	29.10^0	1.5	NA
11	Chookumau, Mustang	83.70^0	29.80^0	0.2-0.5	21
12	Singha Tatopani, Myagdi	83.30^0	28.20^0	5	54
13	Bhurung Tatopani, Myagdi	83.70^0	28.50^0	1.2	66
14	Ratopani Tatopani, Myagdi	83.80^0	28.90^0	1.5	54
15	Darmija Tatopani, Myagdi	84.08^0	29.25^0	1.0	40
16	Gurja, Myagdi	NA	NA	NA	NA
17	Tareja, Myagdi	NA	NA	NA	NA
18	Dharapani, Manang	84.35^0	28.50^0	0.16	33
19	Chame, Manang	84.23 ^{0}	28.50^0	1.0	55
20	Latamanang, Manang	84.30^0	28.50^0	NA	NA
21	Makaibari, Manang	84.36 ^{0}	28.40^0	NA	NA
22	Sadhu Khola	84.20^0	28.40^0	1.39	69
23	Kharpani, Seti River	84.10^0	28.40^0	0.4	48
24	Mayagdi	85.50^0	28.40^0	2	40
25	Bhulbhule Khar	84.20^0	28.20^0	1.05	34
26	Thuman Theramalspring, Chilime	85.30^0	28.30^0	0.83	48
27	Syabru Bensi, Rusuwa	85.20^0	28.10^0	0.3	34
28	Kodari, Sindhupalchok	83.90 ^{0}	27.90^0	5	42
29	Janakpur, Hotwater well	85.60^0	26.40^0	Well water	38
30	Lende Khola Thermal Spring	85.20^0	28.10^0	NA	NA
31	Chitepani Thermal spring Madi Riverside	84.40^0	28.10^0	NA	NA
32	Setikhola Thermal Spring	83.60^0	28.20^0	0.2	44

NA: Not Available

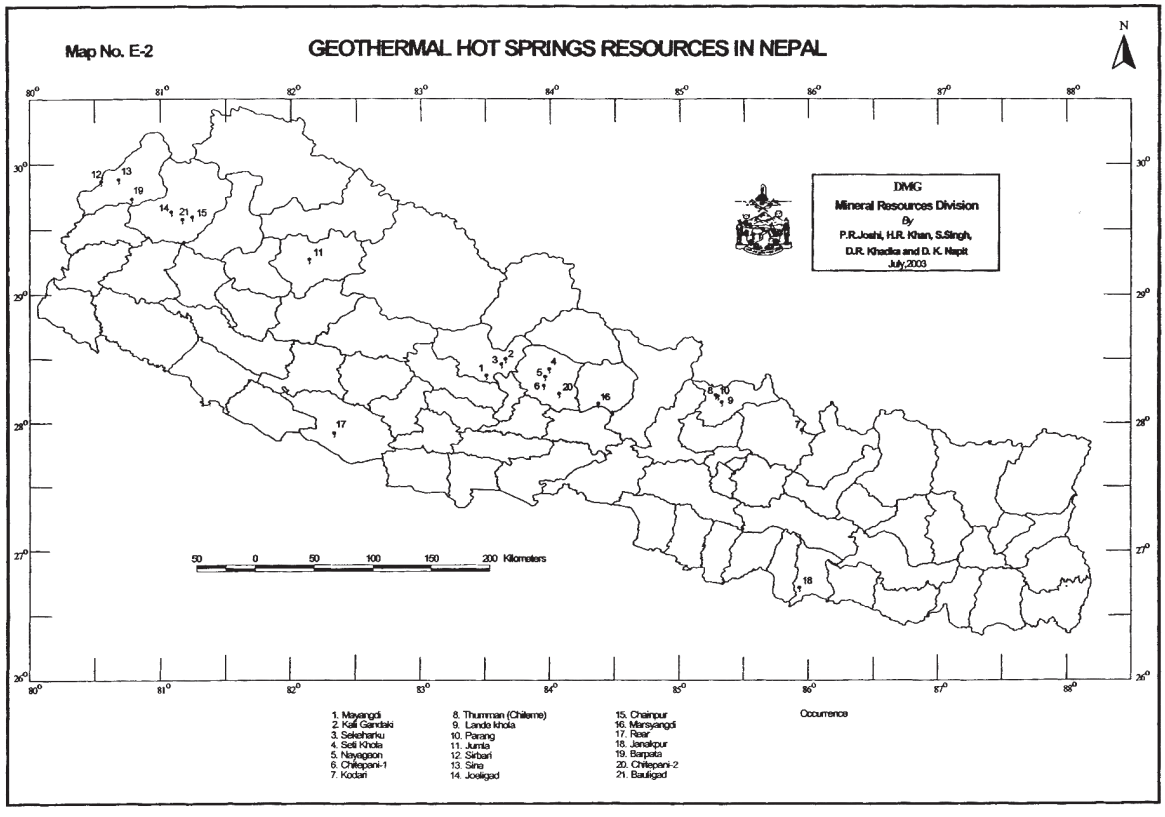

Fig. 2: Locations of hot springs in Nepal (Jnawali 2004)

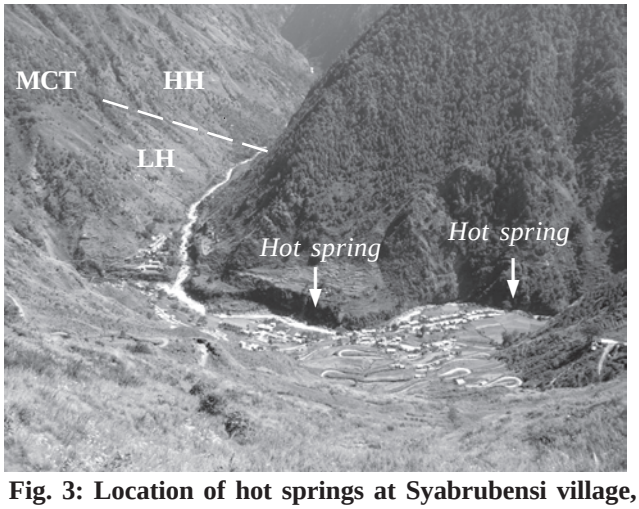

Fig. 3: Location of hot springs at Syabrubensi village, Rasuwa district. HH: Higher Himalaya, LH: Lesser Himalaya; MCT: Main Central Thrust

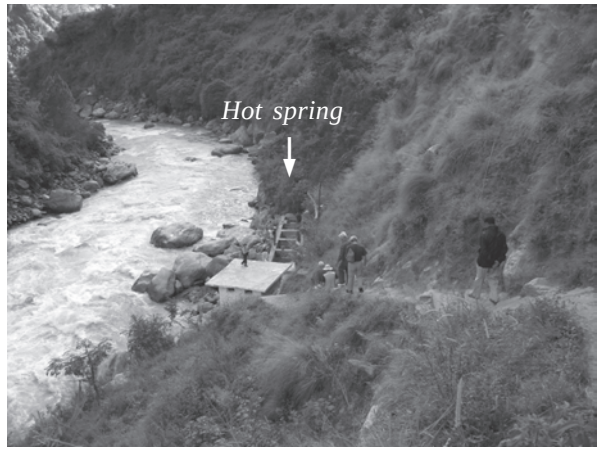

Fig. 4: Hot spring at Syabrubensi village used for relaxation especially by tourists

zone. These late phase of deformation could be responsible for the recharged meteoric water to bring out from deeper depths to the surface as hot spring.

LOCATIONS OF HOT SPRING IN NEPAL

Most of the hot springs in Nepal is still unidentified. Geologically, the hot springs are mainly located around the Main Central Thrust zone and few in the Siwalik hills near to Main Boundary Thrust (MBT). The location of the hot springs is given in map of Nepal (Fig. 2; Jnawali 2004). According to Sharma (1990), these are located in two linear belts: the Main Central Thrust, an indicator of base of thrust and Churia hill. Mineralogists estimate at least 50 hot springs in Nepal. These springs contain alkaline with sulphuric odor. Kandel (2007) has studied the geology, geochemistry and

Fig. 5: Hot springs at Tatopani-Kodari used for religious, bathing, medical purposes by Nepalese people

medical values of Singha Tatopani and Bhurung Tatopani, Myagdi, western Nepal and compiled the different hot spring locations of Nepal Himalaya (Table 1), but the locations of the eastern region of Nepal are not included here.

USES OF HOT SPRING IN NEPAL

On the basis of surface temperature of the hot springs, the spring can be used for electricity production (if temperature is higher than 150 ^{0}C) and swimming pool, mushroom growing, soil warming, greenhouses, foodstuff drying, animal husbandry, etc. (if temperature is less than 150 ^{0}C; Kandel 2007). In Nepal, the temperature of the hot spring is less than 150 ^{0}C. Therefore, it is mostly used in local communities for biogas plant, tourist recreation centre, laundry and therapy only. In the tourist area especially at Tatopani of Myagdi district, Syabrubensi area of Rashuwa district (Figs. 3 and 4) and Tatopani-Kodari of Sindhupalchowk district (Fig. 5) the hot springs are used for the recreation (bathing) as well as therapy purposes. Sometimes the spring is used as a pilgrimage site with an environment to meditation.

CONCLUSIONS

In Nepal Himalaya hot springs correspond to the exit points of meteoric water which is recharged on the High Himalaya (Higher Himalaya and Tibetan-Tethys Himalaya) and Tibetan plateau and the geothermal circulation meet high temperature at great depth and it is drained out along the Main Central Thrust (MCT) zone to the surface. Few hot springs also exit in Siwaliks around the Main Boundary Thrust. Due to low temperature of hot springs, these are mainly used only for community levels such as recreation tourist centre, theraphy (for treatment of rheumatism, gout and skin diseases) and religious purposes.

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Numerical geodynamics simulation in the context of Nepal

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ABSTRACT

Numerical simulation is a powerful tool to analyze the geodynamics process. It is based on solving the partial differential equations (PDEs). Until now, Nepal lacks the curriculum of numerical geodynamics in undergraduate and graduate levels in the universities. Numerical geodynamics is a potential subject in Nepal without a big investment.

Keywords: Numerical geodynamics, simulation, geodynamics courses, university of Nepal

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INTRODUCTION

Numerical simulation is a powerful tool to analyze the geodynamic processes. A good knowledge of basic linear algebra, derivatives, basic mathematical theory, continuum mechanics and partial differential equation is the base of the numerical simulation. Numerical simulation is the key to understand the vast dynamic processes such as subduction (Minear and Toksoz 1970), lithospheric extension (Marotta et al. 2009), collision (Bird 1978), slab break off (Zoltnik et al. 2008; Yoshioka et al. 1995; Yoshioka and Wortel 1995), intrusion emplacement (Woidt 1978), mantle convection (Torrance and Turcotte 1971; Cserepes et al. 1988; Houseman 1988) and planetary core formation (Golabek et al. 2009). Now days, numerical modeling has become an essential approach in geosciences in general and in geodynamics in particular. Numerical modeling in geosciences is widely used for both testing and generating hypothesis. Geo-modeling and geo- visualization play a strong role in relating different branches of geosciences (Gerya 2010). Direct observations and geophysical observations only are not sufficient to analyze the deep crustal processes. Numerical modeling is a necessary tool for geodynamics since tectonic processes are too slow and too deep in the earth to be observed directly.

GEODYNAMIC SIMULATION METHOD

Numerical simulation is based on solving partial differential equations of continuum mechanics. Two principal methods are used for solving partial differential equations (PDEs): numerical and analytical. Analytical methods are restricted to relatively simple problems and cannot be applied to a general case. So the distribution of field variables in space and time is rather complex to analyse using the analytical methods. So analytical methods are useful in understanding geodynamic process and are used to testing accuracy in of numerical codes. Numerical methods for solving the PDEs are universal and can be applied for both continuous and discontinuous distributions of field variables (Gerya 2010). Many numerical methods like finite element (FE), finite difference (FD), finite volume (FV), spectral methods and potential field methods are popular in Earth Science.

For example, Finite Element Method (FEM) is robust and had been used extensively in Earth sciences. Finite elements are the methods for solving boundary value problems in which one divides the domain of the problem into little pieces over which the solutions is approximated using polynomials. The little pieces are finite elements and the polynomials are called the shape functions. The finite element method is one of the most popular tools in structural analysis. The basic concept and detail formulation of FEM can be found in Zienkiewicz (1977) and Zienkiewicz et al. (2005). Basic concept and fundamentals of FE modeling in Earth sciences are also described in Hayashi (2008, 2009).

2-D elastic, elasto-plastic, elasto-viscous and elasto-plastic viscous finite element methods are very popular. Nowadays 3-D methods are becoming more popular due to their more visibility and availability of cheap powerful processor. With the use of knowledge gain in basic geology courses in graduate and undergraduate studies such as Anderson theory of faulting (1951) can be used to classify fault type. Mohr-Coulomb criterion and Byerlee's Law (Byerlee 1978) can be used to analyze and observe the development of faults. Similarly, von Mises' plastic theory can be used to derive the elasto-plastic software. Calculation procedure, basic theory and mathematics depend on the choice of method, type of problem, programming language and choice of rheology.

Nowadays there are many FE software packages such as TECTON, ANSYS, ADELI, ABAQUS, FEVPLIB, LAGAMINE, BASIL and MicroFEM, etc. for the geodynamic modeling. These programs generally written in C, FORTRAN and MATLAB. C and FORTRAN are often used in advanced studies that involve usage of supercomputers and computer cluster. MATLAB is a good language choice for people starting with modeling as it allows both easy computing and visualization.

In geodynamic modeling, the FE (or FD) has been used in order to solve the elastic/elasto-plastic or viscous equations and for that we have to define the geometry of the models and the correct boundary conditions to apply to it {for examples see Fig. 1 of Li et al. 2009 (Fig. 1); Figure 2 of Koirala and Hayashi 2010a (Fig. 2)}. Rock domain/ layer properties, geometry, model dimension and the given displacement strongly influence the results of the numerical modeling. Selection of the suitable rock domain/layer

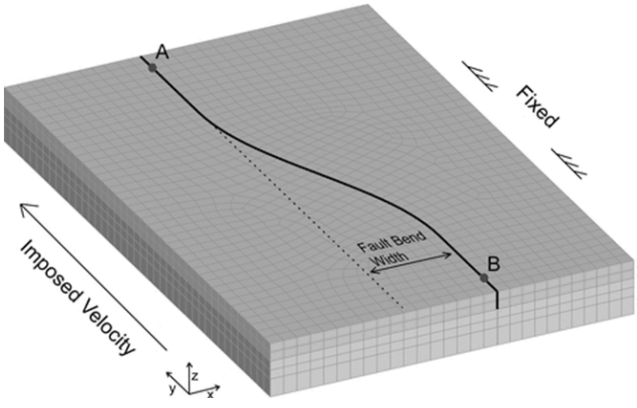

Fig. 1: Model mesh and boundary conditions. The model domain is loaded by an imposed relative velocity on the left-hand side. The black curve shows the surface trace of the vertically-dipping strike-slip fault that cut cross the upper layer (light gray), which represents the brittle (elasto-plastic) upper crust; the lower layer (dark gray) represents the visco-elastic lower crust and mantle (the plastosphere) (Fig. 1of Li et al. 2009).

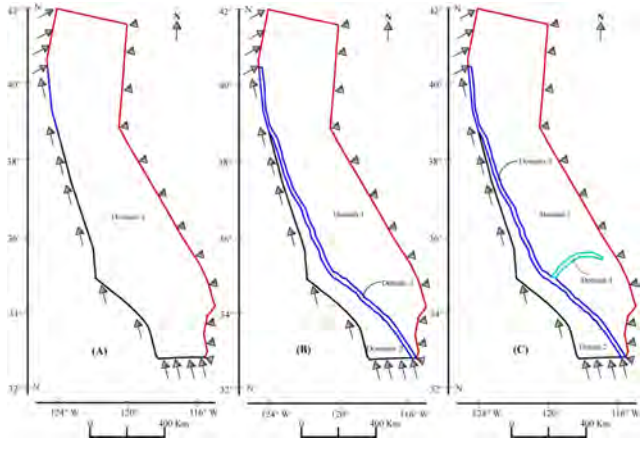

Fig. 2: Geometry and boundary condition of: (A) single domain model, (B) three domains model, and (C) four domains model (Fig. 2 of Koirala and Hayashi 2010a).

Table 1: Major parameters in the model (Table 1 of Li et al. 2009)

Material block	Young's modulus (Pa)	Poisson's ratio	Viscosity (Pa s)	Frictional coefficient	Cohesion (MPa)
Upper crust	8.75×10^{10}	0.25	10^{25}	0.4	50
Lower crust and mantle	8.75×10^{10}	0.25	$4 \times 10^{19} - 10^{21}$	0.4	50
Fault	8.75×10^{10}	0.25	10^{25}	0 – 0.1	10
Fault downward extension	8.75×10^{10}	0.25	$4 \times 10^{19} - 10^{21}$	0 – 0.1	10

Table 2: Physical properties of the different domains applied for the models (A), (B) and (C) (Table 1 of Koirala and Hayashi 2009)

Strength	Depth (Km)	Physical properties				Domain
		Density (Kg/m^3)	Young's Modulus (GPa)	Cohesion (Mpa)	Friction angle (°)	
Weak fault in relatively strong crust	12	2800	80	30	30	Pacific Plate/ North American Plate
		2000	1	1	11	San Andreas and other fault zone
Strong fault in relatively strong crust	12	3000	120	100	45	Pacific Plate/ North American Plate
		2600	50	10	25	San Andreas and other fault zone
Weak fault in relatively weak crust	12	2400	10	5	25	Pacific Plate/ North American Plate
		2000	1	0.5	5	San Andreas and other fault zone

property is crucial. For example for the elastic FE calculation, Young's modulus (E), Poisson ratio (v) and density (ρ) are needed. Similarly cohesion (c) and friction angle (f) are used for the calculation of the failure {for examples see Table 1 of Li et al. 2009 (Table 1); Table 1 of Koirala and Hayashi 2009 (Table 2)}. Similarly, for the elasto-plastic FE modeling, density, Young's modulus, Poisson's ration, yield strength and angle of strain hardening are used to constrain the material properties of different layers {for example Table 1 of Koirala and Hayashi 2010b (Table 2)}. Knowledge of basic mathematical foundation, rock rheology, earth heat transfer mechanism, faulting, gravity flow, subduction process, fluid mechanics, stress strain relation etc. are the base of good numerical modeling in geodynamics.

DISCUSSIONS AND CONCLUSIONS

With the advent of the personal computer with the powerful processor, numerical simulation is in the reach of everyone. Developing country like Nepal, can concentrate on this world class research of numerical simulation in Geodynamics, without a big funding. Until now, Nepal has only two departments of Geology under Tribhuvan University. Department of Geology, Tri-Chandra Campus, is offering 3 years undergraduate studies and Central Department of Geology is offering 2 years Master Course. The course of general geology for under graduate students is well covered with some training in the field but still lacks the base of the research. An additional year of study based on the internships (logical extensions for the future study and/or carrier) and some more seminar type credit courses of the emerging subjects covering their fundamentals is needed for the competitive research/carrier in the future. Many emerging subjects in Earth sciences require expensive instrumentations that the university in the developing country cannot afford.

Numerical geodynamics is a potential subject in Nepal. For this we can add some credit courses of fundamentals of programming in the fourth year of undergraduate studies thus making the world standard undergraduate program and student may continue to numerical geodynamics in his Master's course and further study.

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Probabilistic seismic hazard analysis of the Pokhara Valley, western Nepal

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ABSTRACT

Probabilistic Seismic Hazard Analysis (PSHA) technique has been used to calculate peak horizontal ground acceleration (PGA) at the Pokhara airport, western Nepal. Youngs et al. (1997) predictive relation to predict peak ground motion was used in this study. In addition to calculating PGA, uniform hazard seismic response spectra were constructed at the airport site. The result shows that the Design Basis Earthquake (DBE) is about 0.9g (1 g = 9.8 m/sec^2) at the Pokhara airport (28.2N and 83.98E) for 10% chance of exceedance in 50 years. Similarly, uniform hazard seismic response spectra for three return periods were constructed. The spectra show maximum response at 0.075 (s) natural periods of structures.

Keywords: Seismic hazard analysis, response spectra, Design Basis Earthquake, DBE, Maximum Design Earthquake

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INTRODUCTION

Earthquake is one of the deadliest natural disasters that can neither be predicted nor be prevented from happening. Even a moderate earthquake may result in the loss of a large number of people and property. Regions close to earthquake sources should quantify the level of seismic hazard area exposed in the coming days. Seismic hazard analysis is emerging as an attractive tool to mitigate seismic hazard through the better understanding of tectonics, geology and seismicity.

The Himalaya was formed by the collision of Indian Plate and the Eurasian Plate, which took place about 50 million years ago. Nepal is one of the seismically active regions of the Himalaya. Large number of destructive earthquakes must have contributed in the development of the Himalayan range to its present topography. In the last century the Himalayan range has experienced four great earthquakes. Table 1 summarizes some of the known destructive historical earthquakes which occurred in the Himalaya. Paleoseismic investigation carried out in Nepal has revealed that a great earthquake (M>8.5) may have occurred around 1100 AD in the eastern part of Nepal (Lave et al. 2005). Similarly, the far-west Nepal has been found to have hosted a destructive earthquake around 1505 AD and has been verified from the study of historical documentation of earthquakes in the region. The region between the 1905 Kangra Earthquake and 1934 Bihar-Nepal earthquake has been found, not to have produced great earthquake possibly since 1505 (Bilham et al. 1995, 2001). This stretch of the Himalaya has been termed 'Central Himalayan Seismic Gap' by Khattri (1987, 1992). The region in the west of Kathmandu, including Pokhara Valley has more probability of experiencing a large earthquake in the future. Pokhara is a touristic place as well as a business hub in the western development region of Nepal. In recent years, the town has witnessed an increase in infrastructure development because of development activities and migration of people from elsewhere.

Nepal is seismically active zone of the world, which has experienced several disasters of seismic origin in the past. It has been learnt that the region between 1905 Kangra Earthquake (M7.8) and 1934 Bihar-Nepal Earthquake (M8.2) belongs to a seismic gap zone (Khattri 1987) and is believed to have been waiting for destructive earthquake in future. Pokhara Valley is a part of this seismic gap zone and requires proper assessment of seismic hazard in order to mitigate adverse and painful impact of destructive future earthquakes to the people and infrastructures of the region. Seismic hazard assessment of a region helps to design earthquake infrastructures and strengthen existing infrastructures.

PREVIOUS WORKS ON SEISMIC HAZARD ASSESSMENT

Seismic hazard assessment of Nepal has been carried out by a number of personals and institutions. The first assessment was done during the drafting Building code in Nepal (BECA 1993). They have estimated an acceleration of about greater than 0.4 g near Pokhara Valley for 10% chance of exceedance in 50 years. According to Global

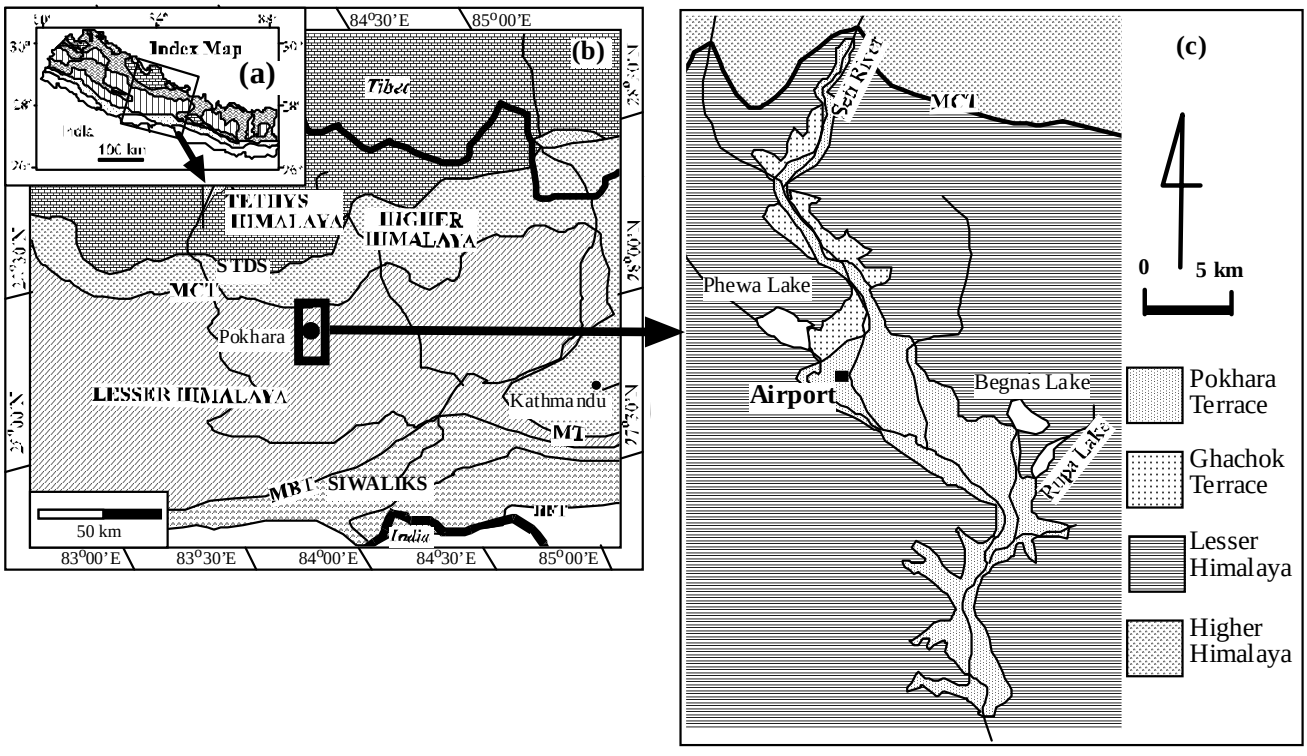

Fig. 1: (a) Index map marking central Nepal Himalaya, (b) Tectonic map of central Nepal Himalaya showing the location of the Pokhara Valley (modified from Paudel and Arita 2000) and (c) Geolgoical map of the Pokhara Valley and surrounding area (modified from Kizaki 1994).

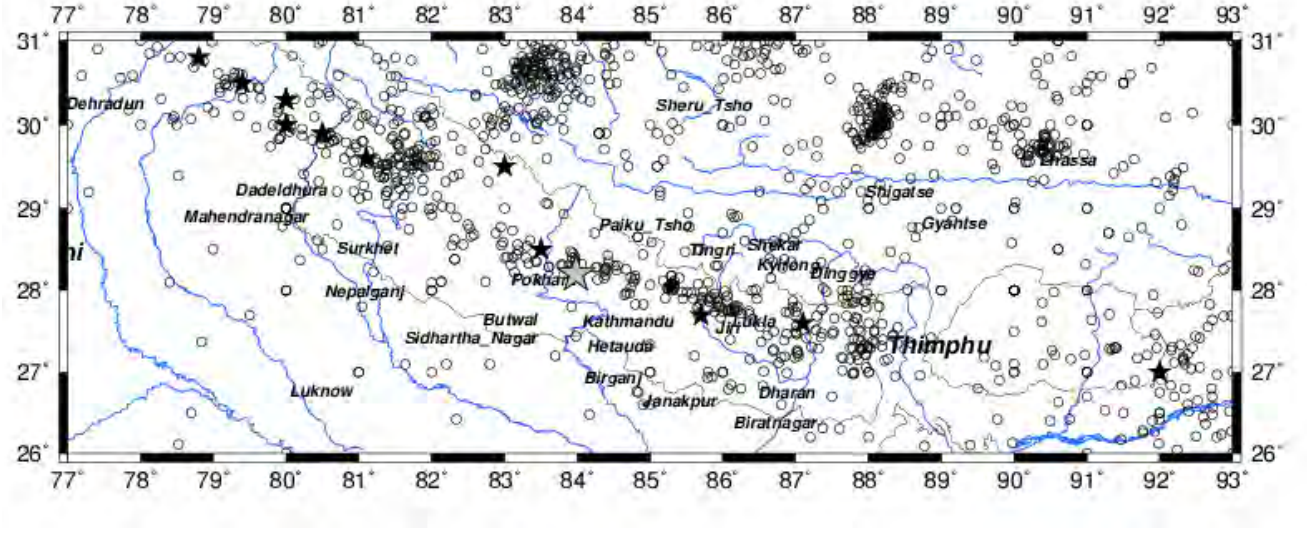

Fig. 2: Seismicity distribution in and around Nepal. The grey star is the location site of current seismic hazard analysis. Open circles are epicenters of earthquakes having magnitude equal to or greater than 4.0 (Source ISC/ UK). Black stars are locations of historical earthquakes (Source: open circles - ISC catalog data (1905-2011) and black stars (Ambrasseys and Douglas 2003, Bilham et al. 2004).

Seismic Hazard Mapping Project (Zhang et al. 1999), peak ground acceleration of 0.4 g to 0.6 g is predicted near Pokhara Valley. Similarly, Pandey et al. (2002) published a seismic hazard map of Nepal. According to this map the PGA is about 0.35 g to 0.4 g for 10% chance of exceedance in 50 years for Pokhara Valley. Parajuli et al. (2008) carried out a seismic hazard assessment of Nepal and has estimated PGA of about 0.4 g for the Pokhara Valley for 10% chance of exceedance in 50 years. Except for Pandey et al. (2002), all other works have used data from United States Geological Survey (USGS) and other published reports on historical earthquakes. Pandey et al. (2002) has used data from local network (from 1995 to 2002) as well as from International Seismological Centre (ISC).

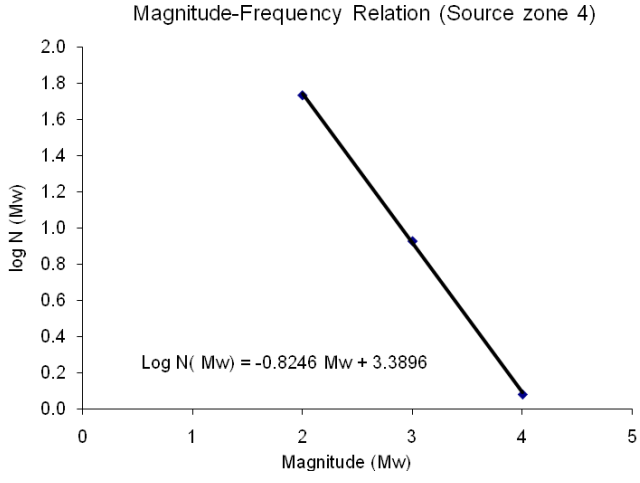

Fig. 3: An example of magnitude-frequency (Gutenberg-Richter) relation (equation at left bottom) for source zone 4. For the source zone 4, the 'a' value is 3.38 and 'b' value is 0.82.

GEOLOGICAL SETTING

The Nepal Himalaya consists of four main thrust-bounded litho-tectonic units; the Sub Himalaya (Siwaliks), the Lesser Himalaya, the Higher Himalaya, and the Tibetan-Tethys Himalaya from south to north, respectively (Gansser 1964, Fig. 1a). The Siwaliks is bordered in the south by the Main Frontal Thrust (MFT) and in the north by the Main Boundary Thrust (MBT). It is composed of Tertiary molassic sediments. The Lesser Himalaya is bordered by the MBT in the south and the Main Central Thrust (MCT) in the north. It is composed of Late Precambrian to Early Paleozoic metasedimentary rocks covered in parts by the Precambrian metamorphic crystallines. The Higher Himalaya is bounded by the MCT in the south and the South Tibetan Detachment System (STDS) in the north. The Higher Himalaya is made up of Precambrian high-grade metamorphic crystallines. North of the STDS is the Tibetan-Tethys Himalaya composed

Table 1: Historical destructive earthquakes in the Himalaya (source: Bilham and Ambraseys 2004)

Date	Latitude	Longitude	Mw	Location
1505 June	29.5	83	8.2	Lo Mustang/Nepal
1555 September	33.5	75.5	7.6	Sri Nagar
1720 July	30	80	7.5	Uttar Pradesh
1803 September	31.5	79	8.1	Uttar Pradesh
1833 August	27.7	85.7	7.7	Nepal
1885 May	34.1	74.6	6.4	Sri Nagar
1905 April	33	76	7.8	Kangra
1906 February	31.5	77.5	6.4	Bashahr
1916 August	29.9	80.5	7.3	Uttaranchal
1926 July	30.3	80	6.5	Uttaranchal
1934 January	27.6	87.1	8.1	Nepal-Bihar
1936 May	28.5	83.5	7	W Nepal
1941 January	27	92	6.8	Shillong
1945 June	30.3	80	6.5	Uttaranchal
1945 June	32.8	76.1	6.3	Chamba
1947 July	28.8	93.7	7.3	Assam
1950 August	28.7	96.6	8.5	Assam-Tibet
1967 February	33.6	75.3	5.6	Anantnang
1980 July	29.6	81.1	6.5	W. Nepal
1991 October	30.8	78.8	6.8	Uttarkashi
1999 March	30.5	79.4	6.4	Chamoli

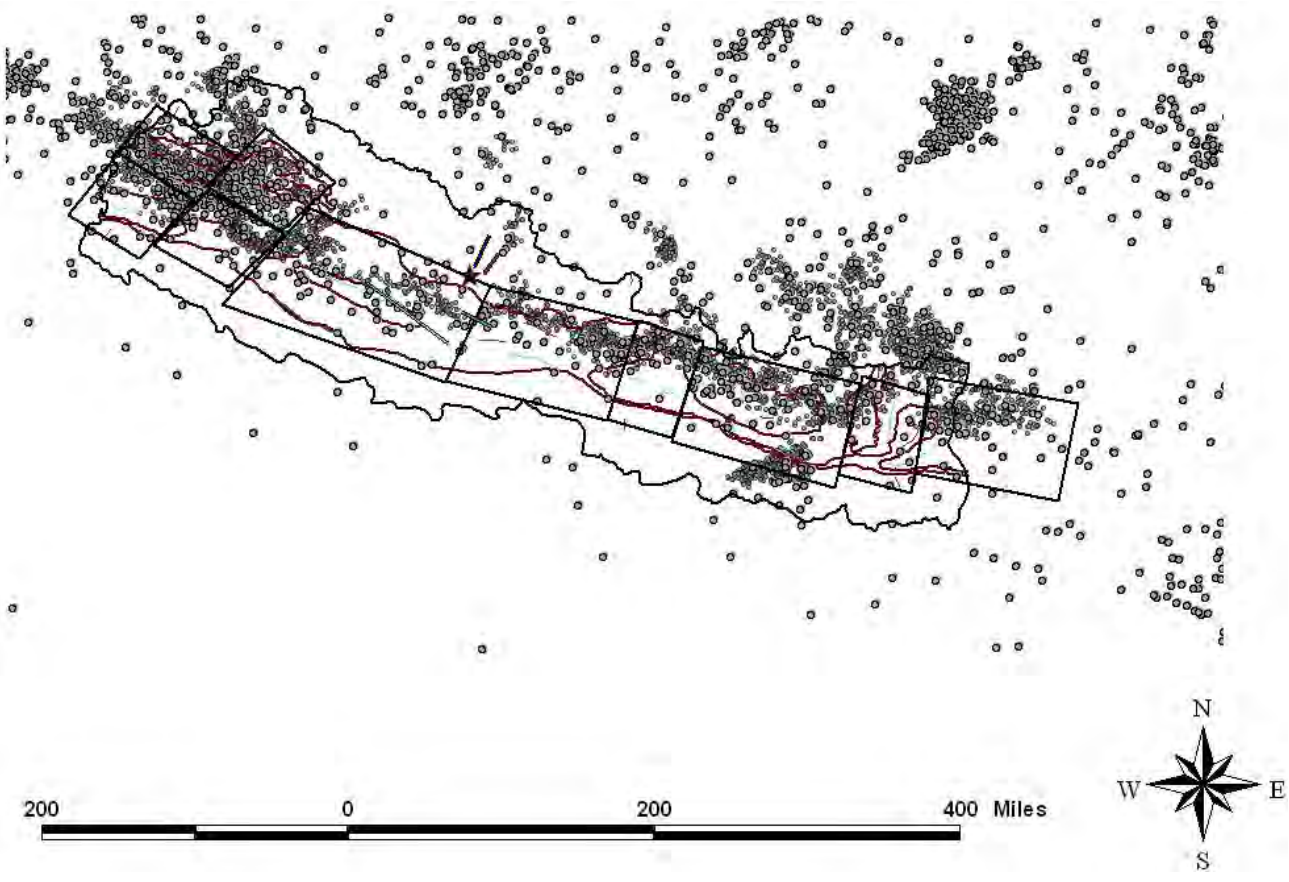

Fig. 4: Delineated potential earthquake sources used in this study. The sources are similar as in the Seismic Hazard map of Nepal by Pandey et al. (2002).

of Cambrian to Eocene fossiliferous sedimentary rocks (Fig. 1b).

The three major north-dipping thrusts, i.e., the MCT, MBT and MFT, propagated from north to south with time and splays-off an underlying horizontal décollement known as the Main Detachment Fault (MDF) (Schelling and Arita 1991) or the Main Himalayan Thrust (MHT, Zhao et al. 1993). The South Tibetan Detachment System (STDS) marking the boundary between the Higher Himalaya and the overlying Tibetan-Tethys Himalaya is a normal fault system (Burg et al. 1984; Burchfiel and Royden 1985; Burchfiel et al. 1992).

Pokhara Valley is a unique intermountain basin extending about 50 km in NW-SE direction and an average width of 5 km. The valley lies in the Midland zone of the Lesser Himalaya. The basement geology of the valley consists of mainly Precambrian Kunchha Formation. The valley fill sediments are mainly coarse-grained gravels, weakly to strongly cemented by calcareous materials. These sediments are the results of the major episodes of debris flow events. The debris had possibly dammed the tributaries of the Seti River forming various lakes in the east and west of the valley. The valley sediments form two main terraces, namely the Ghachok Terrace and Pokhara Terrace (Yamanaka et al. 1982) (Fig. 1c). The Ghachok Terrace is composed of angular to surrounded pebbles, cobbles and boulders. It is about 100 m thick. The Pokhara Terrace is about 90 m thick and is composed of sub-angular to sub-rounded pebbles and cobbles.

SEISMICITY OF THE POKHARA REGION

Pokhara Valley is situated at about 50 km in the south of the seismicity belt of Nepal (Fig. 2). The figure shows that the valley must have been shaken repeatedly by M>4.0 earthquakes which occurred in the north of the valley. Additionally, a very large and destructive earthquake has been believed to have occurred in 1505 in the north of Pokhara and around Jomsom (Bilham et al. 1995, 2001, Ambraseys and Jackson 2003). The earthquakes are mostly shallow focus earthquakes and the depth of focus lies between 10 km and 20 km (Pandey et al. 1999).

DATA SOURCE FOR THE PRESENT STUDY

The required data are collected from the National Seismological Centre (NSC) of Department of Mines and

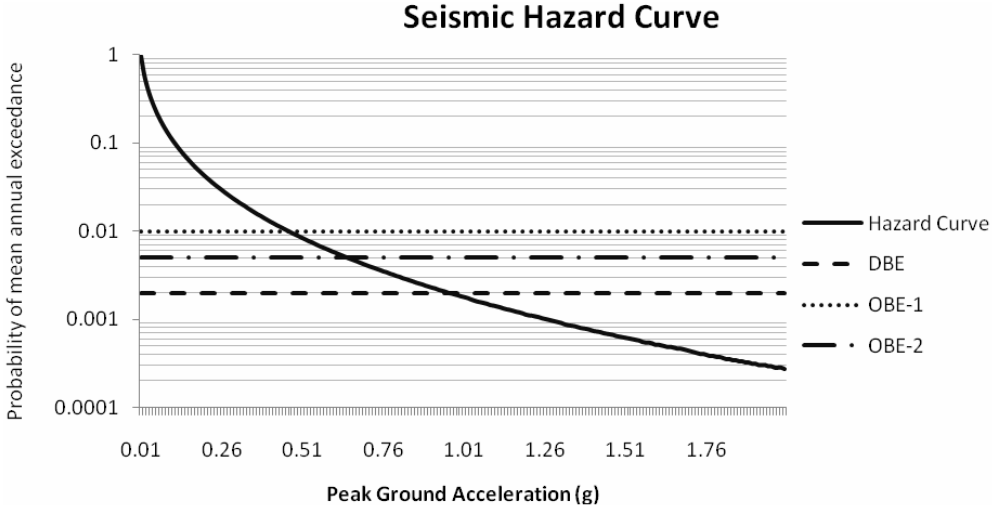

Fig. 5: Seismic hazard curve for Pokhara Valley calculated at a rock site

Geology (DMG) of Nepal and International Seismological Centre (ISC), UK, recorded between 1995 and 2007. The used data ranges in magnitude from Local Magnitude (ML) 2 to 6.3. Dependent events (aftershocks) have been removed from the catalog in order to include independent events only. These data are used to derive Gutenberg-Richter relation (an example is given in Fig. 3) of identified source zones in order to estimate 'a' and 'b' values. Gutenberg-Richter relation (Equation 1) predicts the relative number of small and large earthquakes.

$$\log \lambda_m = a - b\,m \quad [1]$$

Where λ_m is the annual rate of exceedance of earthquake of magnitude greater than or equal to 'm'. 'a' and 'b' are seismic activity parameters of specific region.

Local magnitude (ML) from the catalog data is converted into moment magnitude (Mw) using the equations (2) through (4). The ML is first converted into Ms using regression analysis (Equation 2; Rajaure et al. 2011) between Ms from International Seismological Centre (ISC), UK and local magnitude from DMG, Nepal. The surface magnitude (Ms) is then converted into seismic moment (Mo) using regression relation established by Ambrassey (2000). Equation 4 is next used to get moment magnitude from seismic moment (Kanamori 1978).

$$Ms = 0.6055\ ML + 1.4794 \quad [2]$$

$$\log (Mo) = 19.08 + Ms \quad [3]$$

$$Mw = 2/3 \log (Mo) - 10.73 \quad [4]$$

METHODOLOGY

Probabilistic Seismic Hazard Assessment (PSHA) technique of Cornell et. al (1979) was used to predict ground motion in Pokhara Valley. As local attenuation relation does not exist in the case of Nepal Himalaya, Youngs et al. (1997) relation was used, that is considered best for subduction earthquakes (Equation 5).

The PSHA has four step processes. The first step is the collection of database of earthquake and active faults, and identification of potential seismic sources. The second step is the parameterization of potential sources in terms of magnitude and distance. The third step is the calculation of ground motion using relevant attenuation relation and the fourth step is the expression of ground motions in terms of mean annual probability of exceedance incorporating uncertainties associated with the location, magnitude and timing of earthquake. The details of the process is given by Kramer (2007).

Software Used

The FORTRAN77 program has been used to calculate seismic hazard (Rajaure 2010). The program follows the method of Cornell et al. (1979) as explained by Kramer (2007). The program requires magnitude-frequency relation, maximum potential magnitude and delineating coordinates of the source zones. The program divides every source zone into 10,000 small blocks and assigns equal probability of earthquake occurrence in each block. Similarly the program takes account of intermediate earthquakes in every source zone and calculates probability of every intermediate magnitude. The details of this process are explained in Kramer (2007). The above processes take uncertainties associated with magnitude and location of earthquakes in to account. The peak ground acceleration and spectral acceleration are calculated using Youngs et al. (1997) attenuation relation at the site of interest (Equation 5).

$$\ln(y) = 0.2418 + 1.414M + C_1 + C_2(10 - M)^3 + C_3 \ln(R_{rup} + 1.7818e^{0.554M}) + 0.00607H + 0.3846Z_T \quad [5]$$

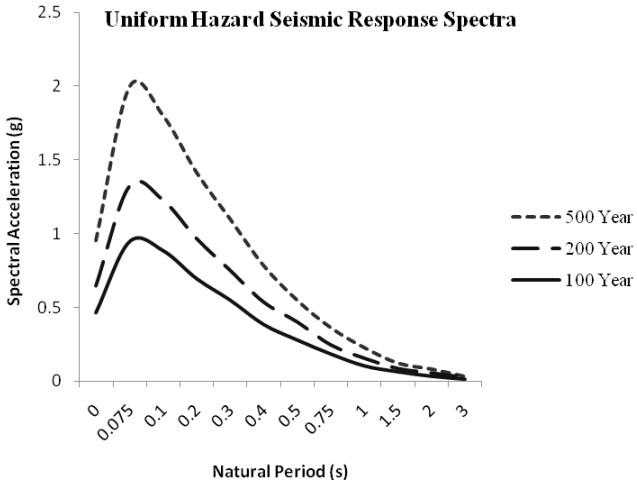

Fig. 6: Uniform hazard seismic response spectra at the Pokhara Airport calculated at 5% damping on hard rock site. The maximum response would occur on structures which have natural frequency 0.075 (s).

Where (y) is acceleration in g (1 g = 9.8 m/s^2), M is magnitude of earthquake, R_{rup} is the source to site distance in km, H is the depth of focus in km. C_1, C_2, C_3 are constants. The standard deviation sln(y) is given by C_4+C_5M.

DELINEATION OF EARTHQUAKE SOURCES

The local earthquake data was relocated using double difference relocation technique developed by Waldhauser and Ellsworth (2000). Double difference relocation is a high resolution technique to image active seismic structures. After relocation, the seismicity is better organized and represents active seismic structure at the front of the Higher Himalaya. Identification of potential earthquake source zones is based on different investigations carried out in the field of geodesy (Bettinelli et al. 2006), vertical uplift (Jackson and Bilham 1994) and geological structures of Nepal. Ten areal sources in Nepal Himalaya have been identified and delineated (Fig. 4). These sources are small modification from Pandey et al. (2002). Though there are many faults in Nepal, but seismic characteristics and recurrence relations of earthquakes on these faults are not known and some faults even have not been found to be associated with any earthquakes during the past 15 years of data recorded in Nepal. All such faults' possible effects included in the aerial sources are used in this study.

Probability of annual exceedance of target accelerations (ranging from 0.01 g to 2.0 g at an increment of 0.01 g) is calculated on account of all possible earthquake sources, all possible site-source distances and all possible magnitude ranges. As the level of target acceleration goes on increasing, the probability decreases accordingly. The hazard curve at a rock site is given (Fig. 5). The design basis earthquake (DBE, calculated at 10% chance of exceedance in 50 years, with a return in 475 years) has a value of 0.9g. OBE-1 is operating basis earthquake (OBE) calculated at 50% chance of exceedance in 50 years and OBE-2 is OBE at 50% chance of exceedance in 100 years. The maximum design earthquake (MDE), defined as that earthquake which has 2% chance of exceedance in 50 years (return in 2500 years) is about 1.6 g. However, such a definition of MDE is in practice in the seismic hazard assessment of nuclear power plants and other large critical structures.

Uniform hazard seismic response spectra at 5% damping was constructed, which is commonly used in earthquake engineering application. It is the response of structures of different fundamental periods to same input seismic ground motion. The structures of different fundamental periods respond differently to the same input seismic motion. Seismic response spectra are useful to design new earthquake resistant structures and in the evaluation of existing structures. The spectra have been constructed using probabilistic approach. The spectral accelerations are constructed for three different return periods (Fig. 6).

DISCUSSIONS

Seismic hazard analysis of a region depends up on the knowledge of tectonics, earthquake history, earthquake characteristics and local attenuation relation. It is noteworthy that, monitoring of earthquake started in Nepal about 25 years ago and systematic database is available after 1995 only. Seismic hazard analysis requires earthquake data as much as possible since very long past. In the case of Nepal, such data is scanty and is available after 1215 AD only. The current research work is based on available earthquake data from the network of DMG.

Though there are many active faults in Nepal, but most of them are not associated with earthquake activities. It is difficult to derive earthquake recurrence rates to these faults. In this study, aerial sources have been used from Nepal only. Aerial sources have been used because of the fact that earthquakes originate in the north, their rupture propagates towards south and are expressed along the Main Frontal Thrust in the south, at the time of large earthquakes.

Unlike previous studies in the region, recurrence relations are established for every identified source zone. Parajuli et al. (2008) have used a single recurrence relation all over Nepal and Pandey et al. (2002) have used two recurrence relations one in the east of 82ÚE and other in the west of 82ÚE. Such recurrence relations are expected to be more realistic and represent earthquake recurrence better than in previous studies.

We have estimated DBE of 0.9 g, corresponding to 10% chance of exceedance in 50 years (return period of 475 years) for a rock site. According to Trifunac and Brady (1975), this DBE (PGA) is equivalent to an intensity of about X on modified Mercalli Scale (MMI). There are reports in 1950 Assam Earthquake and 1934 Bihar-Nepal Earthquake that stones were thrown into air by ground

shaking indicating PGA might have exceeded 1 g, therefore DBE of 0.9 is not impossible in the seismic gap should a large earthquake occur in that region. The response spectra show that structures of 0.075 (s) natural periods would have maximum spectral acceleration. However, such structures are very small, very rigid and rare in practice.

CONCLUSIONS

The result shows that the Pokhara Valley has high level of seismic risk. The DBE is about 0.9 g and it is possible because >1 g ground accelerations were reported during 1934 and 1950 earthquakes. The result of this study is based on relatively large volume of local data of earthquakes used to derive recurrence relations. The recurrence relations have been established for identified (individual) source zones; therefore the recurrence relations are better, realistic and representative of the source zone.

Considering the earthquake of 1505 (Bilham et al. 2004) in the same region, Pokhara Valley has high possibility of similar earthquake in near future in comparison to other parts of Nepal. Seismic hazard analysis depends on the completeness of earthquake database of the region of concern. The work needs to be repeated at regular interval to update and improve seismic hazard as new data comes from earthquakes and active faults. A local seismic wave attenuation model is very important to estimate seismic hazard more precisely, which is lacking in the case of Nepal.

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Approaches of paleoclimatic reconstruction from lake sediment archives: An overview

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ABSTRACT

Instrumental temperature record of the past 150 years indicates that the Earth has warmed by an average of 0.8 °C, but this record is not long enough to determine if this warming should be expected under a naturally varying climate, or if it is unusual and perhaps due to human activities. It is, therefore, critical to examine climate change going back to the past hundreds and thousands of years, and this type of study is known as paleoclimatology. Paleoclimatology uses a variety of physical, chemical and biological proxy (indirect) information preserved in rocks, sediments, ice sheets, tree rings, shells, microfossils, and corals and interpret these records to explain past climatic condition. The deposition or growth rate of the proxy materials are influenced by the climatic conditions of the time in which they were laid down or grew. Literature sources accessed in this study reveals that one area that has advanced greatly over the past four decades or so in paleoenvironmental studies is our ability to reconstruct past climate from the proxies contained in lake sediments. This article gives an overview of the state of the arts in paleoclimatic reconstruction from lake sediments archives.

Keywords: Paleoclimatology, paleoclimate reconstruction, lake sediment archives, climate change, climate proxy

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INTRODUCTION

Climate change

From a human perspective, climate change is the departure from the expected average temperature and precipitation for a given place and time of the year. Climate change can be natural and/or anthropogenically induced, and it is a growing concern whatever the cause(s). The instrumental temperature record indicates that the Earth has warmed by an average of 0.8 °C from AD 1860 to the present (Easterling and Wehner 2009). However, this 150 years record is not long enough to determine if this warming should be expected under a naturally varying climate, or if it is unusual and perhaps due to human activities. For this reason, it is critical to examine climate change going back hundreds and thousands of years using natural climate proxy data. The study of past climates is known as paleoclimatology. Knowing the patterns of past climate change can help us predict how climate will change in future.

Climate proxies are preserved physical characteristics of the past that enable scientists to reconstruct the climatic conditions that prevailed during much of the Earth's history. As reliable modern records of climate only began in the 1860s, proxies provide a means for scientists to determine climatic patterns before record-keeping began. Examples of proxies include ice cores, tree rings, boreholes, corals, and lake and ocean sediments. The deposition or growth rate of the proxy materials are influenced by the climatic conditions of the time in which they were laid down or grew. Chemical traces produced by climatic changes, such as quantities of particular isotopes, can be recovered from proxies. Some proxies, such as gas bubbles trapped in ice, enable traces of the ancient atmosphere to be recovered and measured directly to provide a history of fluctuations in the composition of the Earth's atmosphere. To produce the most precise results, systematic cross-verification between proxy indicators is necessary for accuracy in readings and record-keeping.

Interest in the past climate has increased recently due to the need to determine whether human activity or natural climate variability is responsible for the rate and magnitude of present global climate change (Bradley 1999). Mann et al. (1998) showed in a careful study of several paleotemperature proxies that three of the eight years before 1998 had the highest mean Northern Hemisphere temperatures for at least the last 600 years. If things go on pretty much as they have been, climate models predict even further temperature increases, as high as 3-7 °C, over the next 100 years (IPCC 2007), which would drastically alter precipitation and vegetation patterns that in turn badly affect the human population.

However, it should be pointed out that climate models have their own limitations, and it is necessary to test the validity of today's climate models. This can only be accomplished by comparing modelled past climate change with changes that are observed using paleoclimate records. In this regard, it is necessary to provide good field records of past climate change corroborated by multiproxy approach. They have to be of high spatial and temporal resolution and should be more or less evenly distributed in order to investigate possible phase lags between the various climatic signals. It is thus clear that every climatic reconstruction from any location anywhere from the Earth can add a brick toward the final goal, provided that the reconstruction is reliable. Paleoclimate study therefore helps us gain confidence that our computer model simulations of future climate are worth believing.

Lake sediments as a climate proxy source

Lake sediments are formed by materials that originate from within the lake system (autochthonous materials), the inwash of material from the lake catchment (allochthonous materials), and windblown atmospheric inputs beyond the catchment. The geology and geomorphology of the lake basin and the drainage basin, productivity of the lake and the environments around the lake largely influence the composition of sediments. Lakes have potential of keeping continuous deposition, which is commonly high. The sediments contain a number of biological, physical and geochemical information that reflect the lake condition at the time sediment deposits.

Lakes have wide range of geographical and environmental distribution, and come on a large selection of sizes, depths, chemistries, salinity, and origins. Long records from lake sediments are underused archives that fill in the gap in the global coverage of paleoclimate records (Battarbee 2000). Ice cores are limited to Polar Regions and high-altitude ice caps. Tree rings are time-limited, and are most useful across temperate latitudes. Lake sediments record varieties of components that directly or indirectly represent the atmosphere (precipitation, seasonality, temperature, and wind), the terrestrial ecosystem (pollen, insects, fire recurrence, vegetation and organic matter, volcanic eruption, flood, soil development, weathering) and the aqueous system (salinity, evaporation, algal productivity, organic matter, chemistry, sedimentation rate).

Given no significant disturbance in the distribution of sediments once it has been carried to the basin, lake sediment core are early indicators of truly integrated climate change as there is very little lag-time between perturbation and response. Cores can potentially yield multiproxy climatic data at sub-decadal or even at annual resolution. Because of their relative continuity, time resolution, and sensitivity to climate change, and because of the general ability to compare ancient lake sediments with their modern counterpart in the same lake, the scope of the lake sediments for climatic reconstruction is always effective.

Lacustrine records usually can provide the temporal resolution of relevance on human time scale. Because of relatively fast sedimentation rates encountered in many lakes, opportunities exist to calibrate the sediment record of the past one to two centuries directly against historical and instrumental records of environmental change. Moreover, rapid sedimentation rates allow for quantification of the rate of abrupt environmental change. Among the key environments that provide potential multi-proxy sources, lake sediment archives are therefore becoming an increasingly common and important sensor to record paleoclimate signals.

METHODOLOGY

The overview of approaches of paleoclimatic reconstruction from lake sediment archives presented in this paper is largely drawn from paleoclimate literatures. More than 30 books and research papers were studied and the states of the arts in paleoclimatic reconstruction from lake sediments archives highlighted in the literature sources are summarized.

RESULTS AND DISCUSSIONS

Overview of lake sediment archives

One area that has advanced greatly over the past 40 years or so in paleoenvironmental studies is our ability to reconstruct past climate from the proxies contained in lake sediments. However, measurement of different kinds of proxy data is critical for accurate paleoclimatic reconstruction because individual type of data generally have their own merits and as well as shortcomings and each lake is essentially different in its biological, chemical, and sedimentological characteristics. This article gives an overview of the state of the arts in paleoclimatic reconstruction from lake sediments archives. It is by no means an exhaustive list of studies undertaken over the past years, but rather a personal selection. Although limitations exist in each method, the basic idea behind different proxies that record climate change is outlined below.

Diatom

Diatom (Bacillariophyceae) is a species-rich class of siliceous algae, which preserves well in lake sediments, provided salinity is not excessive. Because they can be identified to species level, and their distribution and abundance is sensitive to a range of ecological variables, including water depth, salinity, pH, and trophic status, diatoms preserved in lacustrine sediments are one of the most sensitive indicators of past lake conditions (Bradbury 1988). The reconstructed lake condition in turn can be directly or indirectly linked to climatic condition at the time the sediments deposited. Besides the ecological dependency, diatom, as a climate proxy, can be studied for two aspects, type and abundance.

Temperature appears to have an important effect on the relative abundance of diatom and other freshwater algae. From the sediments of Lake Biwa (Xiao et al. 1997) and Lake Baikal (Colman et al. 1995), it appears that high concentrations of diatoms in the core indicate elevated diatom productivity that characterized interglacial climates and the opposite relation characterized the glacial climates. Diatom productivity in Lake Baikal was low during glacial periods because of increased ice cover and turbidity from silt and clay introduced into the lake from glaciated drainage surrounding the basin (Colman et al. 1995).

The relationship between the species composition of modern diatom assemblage and the chemistry of waters allow quantitative reconstruction of past variations in lake chemistry. Change in salinity in closed–basin lakes indicates hydrological change, i.e., change in evaporation and water supply, which is clearly climate related. Recently an indirect effect of temperature on lake pH values has been derived in the Alpine lakes (Schelske et al. 1995), i. e., climate cooling may cause decreases in pH, and rising temperature increases pH. Decline of pH started at the onset of the Little Ice Age (LIA), with glacier advances in the Alps and increase during warm episodes are also linked to temperature.

Lake depth can be estimated qualitatively by using the relative proportions of diatoms of different life forms; planktonic species indicate deep water; benthic and periphytic species suggest shallow water. Thus lake level fluctuation can be accessed through the study of habitat change, which can result from climatic processes. During climate cooling, lake surface water temperature declines, and the lower temperatures leading to prolonged ice-cover may be responsible for the low percentage of plankonic diatoms (Colman et al. 1995). Certain diatom species are characterstic of oligotrophic waters, others of eutrophic waters; this allows the qualitative reconstruction of lake nutrient status that may be partly influenced by climate.

In Artic and Alpine region, the predicted temperature closely approximates the actual value based on the diatom assemblage study (Smith et al. 1992). In their study, planktonic diatoms generally displayed optima at the higher end of the temperature range, whereas small benthic affinities were positioned at the lower end of the temperature gradient. Thus the fossil diatom data could be used for paleotemperature reconstruction.

Besides the indirect climatic interpretation from the ecological variables, direct temperature inference has also been made from diatoms. For example, the predominance of *Cyclotella comta,* and *Cyclotella ocellata* characterize the warm Holocene and Last Glacial climates, respectively (Diatom Research group for Nojiriko excavation 1993; Adhikari et al. 2002). Similary, some records show a Holocene dominance of *Aulacoseira solida* whereas *Stephanodiscus* assemblage dominates the glacial coeval with cool climate pollen indicators (Bradbury 1988).

Pollen

Pollen in lake sediments has always been a mainstay of continental paleoclimate reconstruction because each genus of plants produces pollen grains with distinct shape. These shapes can be used to identify the type of plant from which they came. For paleoclimatic purpose, modern vegetation distribution in different climatic zones can be considered as analogs of former vegetation cover. Since pollen grains are well preserved in the sediments layers that form in the bottom of a lake, an analysis of the pollen grains in each layer tell us what kinds of plants were growing at the time the sediment was deposited. Inference can then be made about the climate based on the types of plant and their abundance found in each layer (Harrison et al. 1995). Statistical methods for these reconstructions include closest-analog method and transfer functions (Guiot 1987).

Several reliable paleoclimatic reconstructions extending from several thousand years to more than 100 ka has been made worldwide (Ponel 1995). High-resolution studies in which pollen is combined with other paleoecological indicators are especially useful for documenting rapid changes. Pollen can also be combined with diatoms to reconstruct lake-level change.

Varved sediment

Varved or annually laminated sediment reflects the annual cycle of the sedimentation in lacustrine environment. A single annual unit, a varve, is composed of two or more layers or laminae that can be distinguished on the basis of their color, composition and texture, which are indicative of environmental changes. The records of the changes in the structure and composition of seasonal layers can be very useful, if there are no post- depositional disturbances of the sediment surface.

Non-glacial varve can be ferrogenic, calcareous, biogenic or clastic laminations. These biological, chemical, and mineralogical components contain wealth of annually resolved paleoenvironmental information that can be related to climate change. For example, the presence of ferrogenic and calcareous lamina can be indicative of warm condition, as cool condition is not favorable for their formation. Similarly, warm climate produces more biogenic matter, including diatom and other organic fractions, and the occurrence and the thickness of the biogenic varve tend to be higher compare to those under climate cooling. Applying varve as a proxy, Fukusawa (1999) presents a wonderful varve chronologies from Lake Suigetsu and Lake Tougouike in Japan, which extends back to 40 ka permitting reconstruction of high-resolution climate change with Asian Monsoon fluctuation and sea-level changes. Reliable varve sediment based climate reconstructions extending back in time over 10,000 years, have been reported from Lake Holzmaar in western Germany (Zolitschka 1998a) and from Elk Lake in Northern America (Bradbury and Dean 1993).

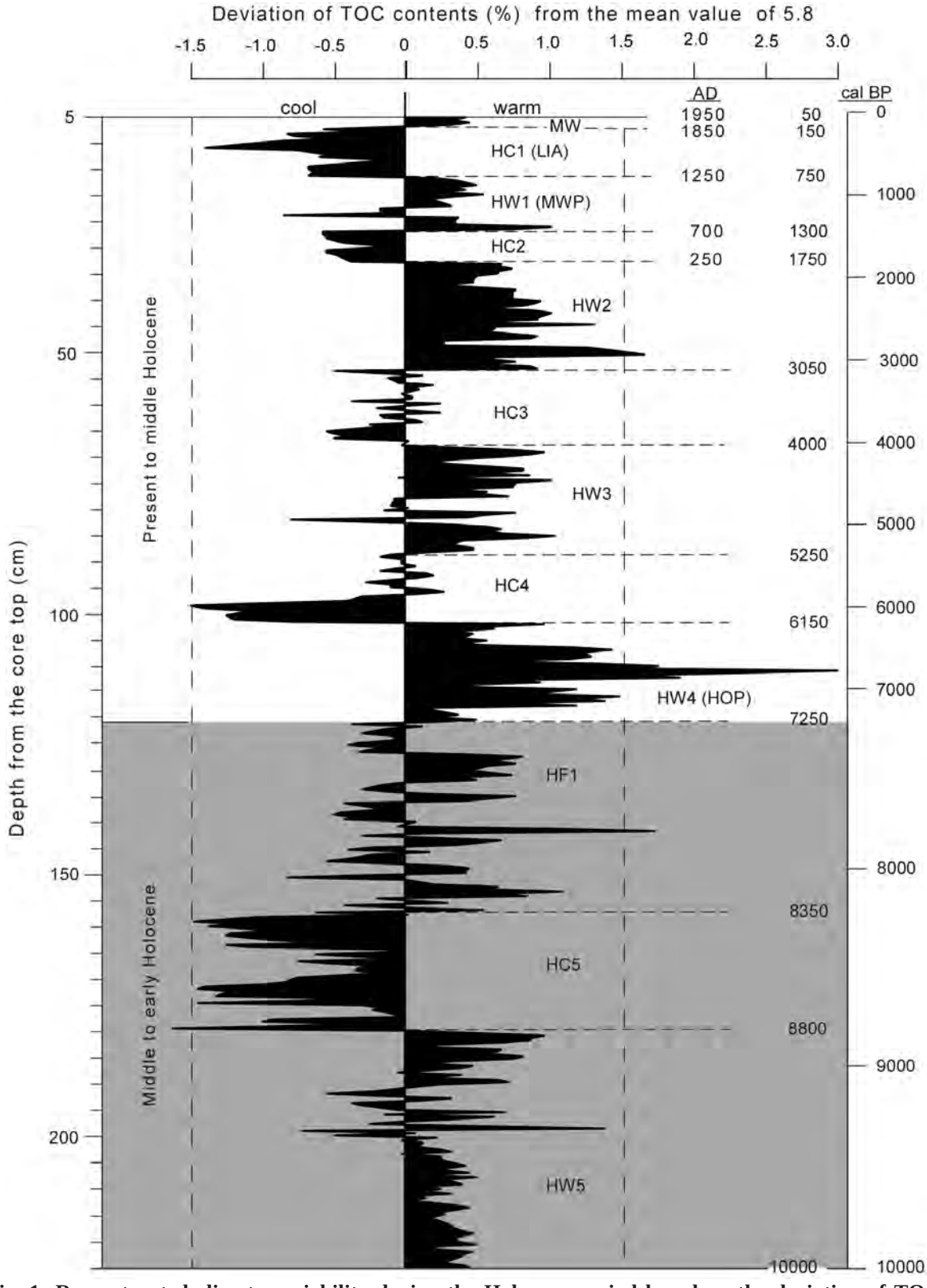

Fig. 1: Reconstructed climate variability during the Holocene period based on the deviation of TOC contents from their mean value of 5.8 %. MW - the modern warming, HC1-5 - Holocene cool phases, HW1-5 - Holocene warm phases, HF1 - Holocene fluctuating phase, LIA - the Little Ice Age, MWP - the Medieval Warm Period, and HOP - the Holocene Optimum (Figure after Adhikari et al. 2002).

Biological records of pollen, diatom, cladoceras can be studied at an annual or even seasonal resolution and the result expressed as the absolute concentration of microfossils provide a very sensitive proxy for the investigation of climate changes. Thickness can be a proxy of the amount of summer precipitation or spring snowmelt, because higher sediment delivery to lakes usually associates with higher amount of snowfall and/or precipitation. Coarse sediment texture is also indicative of prevalence of this situation. In addition to the usefulness of varve as a recorder of exact timing of climatic changes, such as draught cycles, it is useful for calibration of the radiocarbon time scale (Stuiver et al. 1998).

TOC and TN contents

The amount of total organic carbon (TOC) and total nitrogen (TN) in lake sediment is a fundamental property that is a function of autochthonous and allochthonous organic production, bacterial decay, and the rate of clastic sediment input into the lakes. As measures of lake productivity, organic carbon and nitrogen are largely influenced by surface water temperature, which is the reflection of atmospheric condition. TOC and TN contents in sediments are thus critical for paleoecological studies, including paleoclimate (Adhikari et al. 2002). Example of down core variation of TOC and its climatic interpretation is shown in Fig. 1. The ratio of carbon to nitrogen is commonly an indication of source of the organic matter.

Granulometry

In some cases, texture and grain-size of lake sediment can be interpreted directly in terms of climatic variables. For example, as river discharge increases, it becomes capable of eroding relatively more sediment with coarser grains, affecting both texture and grain-size. For this to happen, both weathering process and precipitation in the watershed must be higher, which is favorable during warm climatic condition. Lake water residence period can be another additional factor controlling the sediment coarseness in some small mountainous lakes (Adhikari et al. 2009). It is because, part of the finer particles are likely to be removed from lake through discharge as the water residence period reduces during higher stream discharge, whereas finer particles are likely to retain within the lake during higher water residence period. Except for the short-lived intervals of event sediments (flood, storm), the relative proportion of coarser fraction can be climatically controlled.

Not only warm condition favors sediment coarsening and texture deterioration, but cold climatic conditions may have similar effect, if the lake is located in a snowy area. It is possible through ice rafting process in the lake that could bring coarser fraction in the lake center, which is not possible through stream transportation. Recognition of such ice rafted signature can be very reliable proxy for winter coolness.

Biogenic silica

Biogenic silica (BS) is opaline silica, the mineral of which the diatom frustules are composed. Other components that contribute to BS include phytoliths, chrysophyte cysts, and sponge spicules. BS is one of the major components of lake sediments in many environments. Although water chemistry and sedimentation rates affects the amount of biogenic silica that escape dissolution to be preserved in the sediments, down-core variation of BS reflects primary change in diatom productivity, and hence it is a strong paleoclimate indicator (Colman et al. 1995, Xiao et al. 1997).

Organic geochemistry

Organic matter (OM) that is preserved in lake sediments encompasses a range of compounds, from the simple such as methane, to complex biopolymetric molecules such as lignins and nucleic acids (Killops and Killops 1983). In a lacustrine environment, OM is derived from primary production within the water column and also from terrestrial sources. The accumulation and composition of OM in the sediments is usually influenced by the environmental conditions, such as climate, catchment geology, physical and chemical charactersticks of the lake waters, and the nature of the OM itself. Hence, variations in source materials and conditions can affect the composition of the organic compounds in sediments, and these can potentially be used as a chemical record of past environmental changes.

Certain lipids and pigments have a restricted occurrence in only a few organisms; if they or their derivatives can be identified, then an attempt to discern original inputs to the sediment can be made. For example, biological markers can clearly discern autochthonous and allochthonous contribution to lake sediments, and have potential to be used in quantitative assessment of changing OM inputs. Fossil pigments are also useful for reconstructing the history of productivity, meromixies, and trophic status that in turn helps to understand the past climate.

Sulfur geochemistry

Sulfur exists in a variety of oxidation states, and its amount, kind and geochemistry has been successfully applied to studies of ancient and modern lakes to help understand depositional and diagenetic process related to changes in climate, productivity, and water chemistry (Tuttle et al. 1990). Large systematic changes in the abundance and isotopic composition of pyritic sulfur are generally the result of variations in the supply of sulfate to a lake from rainfall runoff. A Shift to warmer, wetter conditions, such as that experienced by some areas during the early Holocene, may be marked by an increase in the abundance of pyritic sulfur and a negative shift in sulfur isotope composition.

Stable isotopes

A variety of chemical and biological processes causes fractionation of stable isotopes (e. g. C, N, H, O, S) in lake sediments, so that analysis of isotopic composition of various components of the sediment allows inferences about the history of climatic and other environmental conditions in the lake. Oxygen and carbon isotopes in carbonate precipitated from the water column have been most commonly analyzed for this purpose (Schwalb et al. 1994). These two isotopes in temperate lakes reflect the isotopic composition of meteoric water, the composition and source of which has important paleoclimatic implications. These isotopic compositions are subsequently modified by limnological (e.g. evaporation) and biological processes under the climatic influences.

Carbon isotopes of organic matter are another important paleolimnological tool, since photosynthesis causes significant fractionation of carbon isotopes. Therefore it reflects lake productivity, aquatic vegetation type, and other biological factors (McKenzie 1985). Changing environmental conditions can lead to the changing isotopic signature of OM; this can lead to isotopic shift in the composition of sedimentary OM, for example as a result of increasing aquatic productivity.

Carbonate content

Carbonate in lake sediments derives from detrital, authigenic, and biogenic sources, and reflects the chemical limnology of the basin as well as biological activity. The relative amounts of detrital and authegenic carbonate are particularly sensitive to drainage basin conditions of many lakes; both transport of detrital sediment to the lake and chemical precipitation of carbonates respond in different ways to climate changes. The chemistry and mineralogy of authigenic carbonate phases are also sensitive to climatic and drainage basin conditions (Dean et al. 1974). Moreover, Authigenic and biogenic carbonates are the primary materials for many isotopic studies.

Ostracodes

Ostracodes are small bivalved crustaceans that live in many permanent and ephemeral aquatic environments. Ostracode valves, which are made of calcite, are common fossils in lake sediments. Species assemblage as well as the isotope values and trace-metal ratios of their valves provide a wide variety of paleolimnological information (DeDeckker and Forester 1988). For many species, the modern distribution and related environmental variables have been documented. Trace metal ratios (Mg/Ca, Sr/Ca) from ostracode valves are related to water temperature, salinity, and perhaps other factors during calcification. Ostracodes are also a source of biogenic calcite that is at or near isotopic equilibrium with lake water that is useful for isotope analysis (Heaton et al. 1995).

Eolian flux

Studies in Chinese Loess Plateau indicates large variations in eolian accumulation rates that correspond to changes in the environment of the Loess Plateau (Hovan et al. 1991). During interglacials, when loess accumulation slowed and soils formed on the plateau, eolian flux rates were low, but during glacial period's eolian flux in the marine sediments were many times higher. Modern observations show that total dust flux thousands of kilometers downwind of arid regions is mainly a function of conditions in source region, whereas variations in grain-size are more related to changes in wind speed (Rind et al. 1993). As in marine sediments, eolian dust preserved in lake sediments provides direct information regarding changes in the intensity of atmospheric circulation and the aridity of the source area. The grain-size of eolian dust is related to wind intensity, whereas eolian accumulation rates reflect source-area aridity.

As the Japanese Islands are situated downwind from Asia, eolian dustfall events occur due to the northwesterly wind when the weather of inner Asia is cold and dry. Using the eolian quartz flux in the sediment of Lake Biwa, Xiao et al. (1997) successfully reconstructed glacial and interglacial conditions over the past 145,000 years.

Magnetic susceptibility

Mgnetic properties of sediments mainly depend on geological process such as weathering and erosion, or limnological parameters such as lake status and water chemistry. All of these can be climatically influenced and change the mineralogy, particle-size distribution and abundance of magnetic minerals in the sediments. Most of magnetic grains are too small and occurs in concentrations too low to be observed directly, but can be characterized indirectly by the measurement of magnetic susceptibility. During cold periods the magnetic mineralogy is dominated by strongly magnetic mineral from the catchment area, while soil formation in the catchment and higher organic production in lake affect the properties of lake sediments during warm and humid period (Dearing et al. 1998). Therefore, glacial and interglacial periods are characterized by high and low magnetic susceptibility, respectively.

X-ray mineralogy

Mineralogy of the clay and fine silt size fraction is useful in many paleoenvironmental studies. For example, it can be used to distinguish between sediments derived from within the basin versus those imported from extra-regional sources by wind. The contents of quartz and illite higher in the sediment during glacial period and lower during Holocene are serving as the proxy of strength of winter monsoon in Asian Continent (Kumon et al. 2000). At somewhat lower resolution, the suite of clay minerals, such as kaolinite, illite and montmorillonite transported from lake catchments are

responsive to temperature and precipitation, and to climatically meditated watershed process such as soil erosion (Jones and Bowser 1978). It is because kaolin content in sediment gets higher during warm climatic condition, as weathering process accelerates during climate warming.

CONCLUSIONS

Paleoclimatology has wider implications for climate change today as scientists often consider past changes in environment to reflect on the current situation. Knowing the patterns of past climate change can help us predict how climate will change in future. Given no significant disturbance in the distribution of sediments once it has been carried to the basin, lake sediment core are early indicators of truly integrated climate change as there is very little lag-time between perturbation and response. Lake sediments can potentially yield multiproxy climatic data at sub-decadal or even at annual resolution. Because of their relative continuity, time resolution, and sensitivity to climate change, and because of the general ability to compare ancient lake sediments with their modern counterpart in the same lake, the scope of the lake sediments for climatic reconstruction is always effective. Content of diatom, pollen, organic carbon and nitrogen, biogenic silica, ostracodes, eolian flux, and carbonate; variation in - sediment grain-size and mineralogy, magnetic susceptibility, organic and sulfur geochemistry, and stable isotopes (carbon and oxygen) ratio; and presence of varved sediment are reliable lake sediment archives for paleoclimate reconstruction.

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Field excursion guidebook series on geology, natural hazard and vegetation of the Nepal Himalaya

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ABSTRACT

The Himalaya is the result of the collision between Indian and Eurasian subcontinents which is the largest, highest and still rising mounatin range on our planet. It has a wealth of field evidences of geology, geomorphology, climate and flora and fauna. Thus the Himalaya is the best laboratory to study the nature and natural sciences of the mountain building processes and the environment. However, there are only a few excursion guidebooks for common people to introduce on geology and natural hazards in the Himalaya. At present the excursion guidebooks of different regions of Nepal have been published: Kaligandaki Valley, Pokhara - Beni Highway and Sidhartha Highway (western Nepal), Langtang Valley and Arniko Highway (central Nepal) and Dudhkoshi Valley, Everest area (eastern Nepal). These guidebooks can help to the national or international scientists, engineers, teachers, students, planners, trekkers or citizens to collect the information on natural environments especially on geology, natural hazards and vegetations. The using of these guidebooks by tourists has also played an important role for the betterment of eco-tourism of Nepal.

Keywords: Geology, natural hazards, field excursion guidebooks, Nepal Himalaya

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INTRODUCTION

The Himalaya is the largest, highest and most active mountains of the world, and it has still been active changing its mountain topography, climate, vegetation and geology. Consequently, a variety of natural hazards such as landslide, debris flow and soil erosion occur in the mountainous region causing a great loss of life and properties. Therefore, the Himalaya is the best laboratory to study the processes of vivid geology, natural hazards, and vegetation. The Himalaya is divided into different tectonic zones (Siwaliks, Lesser Himalaya, Higher Himalaya and Tibetan-Tethys Himalaya) separated by the major faults (MFT, MBT, MCT and STDS), from south to north. Nepal Himalaya is the longest Himalaya covering about 800 km in length (Upreti and Le Fort 1999; Fig. 1).These different zones have different types of rock types and different geological history. Climatic zones in the moutain range also change drastically from south to north; subtropical, deciduous, coniferous, alpine and tundra. Characteristic natural disaster especially landslide occurs in each tectonic zone.

There have been only a few field excursion guidebooks on geology and natural hazards of the Nepal Himalaya. Therefore, Department of Geology, Tri-Chandra Campus, Tribhuvan University published the first field excursion guidebook of Nepal Himalaya supported by the Japan International Cooperation Agency (JICA) in 2005. Onwards, the process of successive series of guidebook publication is regularly coming up.

The publication of the regular series of guidebook can help to the national or international scientists, engineers, teachers, students, planners, trekkers or citizens to collect the information on natural environments especially on geology, natural hazards and vegetations. These guidebooks are equally useful for local people or government officers. The information of guidebooks will be very important for planners to establish new projects. The guidebooks equally provide information on rocks, minerals, fossils, hot springs, wetlands, natural hazards such as landslide, GLOF, soil erosion, debris flows, environment, trekking route, historic place, cultural places, topography, climate, flora and fauna, and so on.

PUBLICATION OF THE EXCURSION GUIDEBOOKS

The field excursion guidebooks have been published with field observed data collected from different regions of

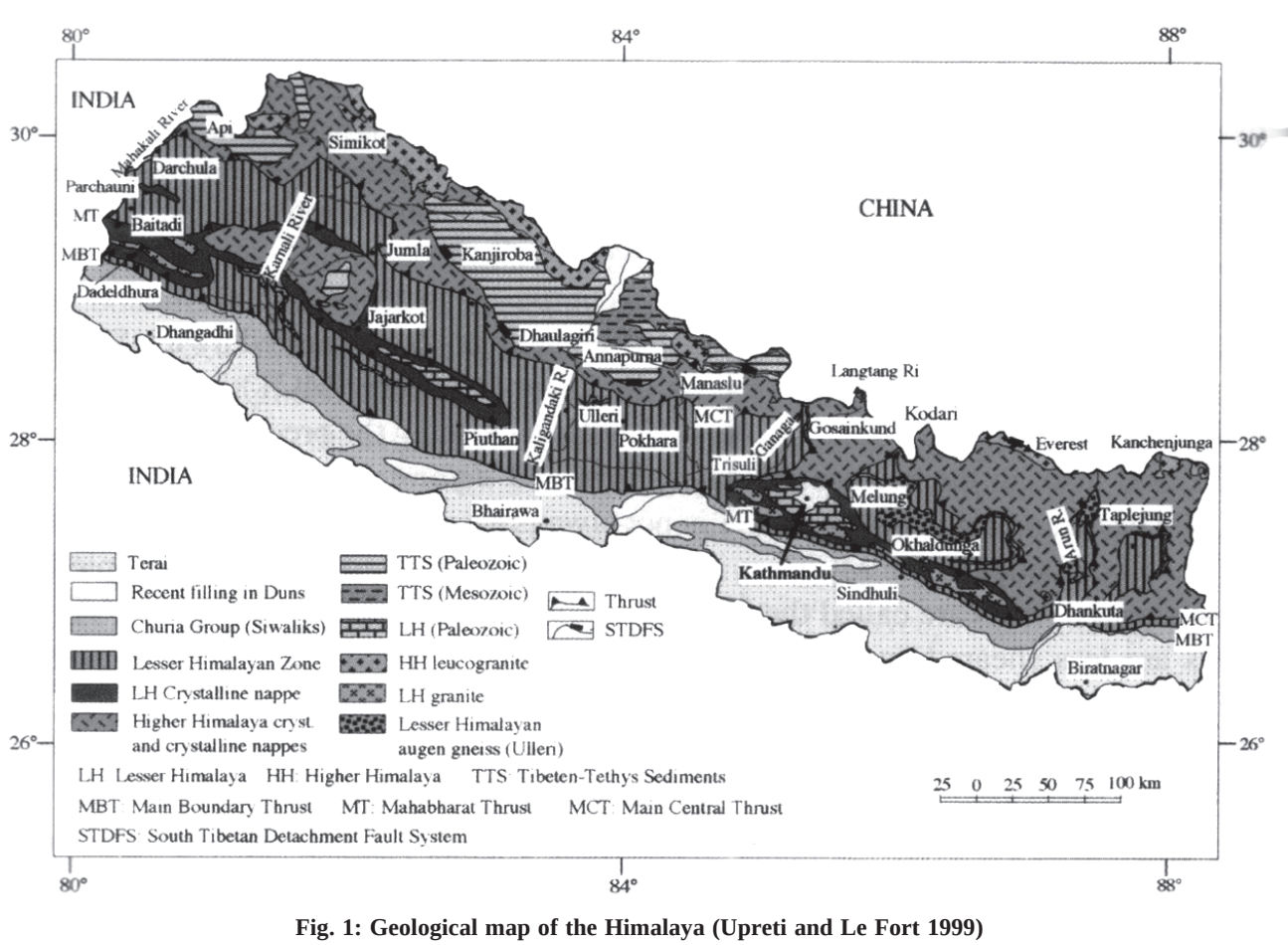

Fig. 1: Geological map of the Himalaya (Upreti and Le Fort 1999)

Nepal: Kaligandaki Valley and Sidhartha Highway (western Nepal), Langtang Valley and Arniko Highway (central Nepal) and Dudhkoshi Valley, Everest area (eastern Nepal). Brief introductions of these guidebooks are given below:

Kaligandaki Valley, Annapurna-Dhaulagiri area, western Nepal

The first guidebook in this series: *Guidebook for Himalayan Trekkers, Series No. 1: Geology and Natural Hazards along the Kaligandaki Valley, Nepal* was published in 2005 (Upreti and Yoshida 2005; Fig. 2)). This guidebook was the first excursion guidebook on geology and natural hazards in Nepal Himalaya published by the Department of Geology, Tri-Chandra Campus, Tribhuvan University as a special publication No. 1 in collaboration with the JICA. Before the publication of this guidebook, an embryonic English version guidebook for field study namely *Geology and Natural Hazards along the Kaligandaki Valley, Central – west Nepal Himalaya* was published by the Department of Geology, Tri-Chandra Campus, Tribhuvan University (Yoshida and Upreti 2004).

Guidebook for Himalayan Trekkers, Series No. 1, in general provides information on geology, natural hazards, geomorphology and climate with the essence of the natural beauty. The content of this guidebook is mainly divided into three parts: (i) general introduction of geoscientific and environmental characteristics of the Himalayan range, (ii) geology and natural hazards of the Kaligandaki Valley and (iii) general physiography, geology and natural hazards with observations points along the Kaligandaki Valley and Pokhara Valley.

Sidhartha Highway, Butwal-Pokhara area, western Nepal

A *Guide book on Geological Section of Sidhartha Highway (Butwal to Pokhara), Western Nepal* was published by the Department of Mines and Geology, Government of Nepal in 2007 (Pradhanaga 2007; Fig. 3). The content of this guidebook is mainly divided into: (i) general geology of Nepal, (ii) geology, geomorphology and natural hazards of the area (Butwal to Pokhara), and (iii) geology along the Highway, and (iv) geology or natural hazards outcrop (spot) description.

Bhupi-Sherchan Marg (Pokhara-Beni Highway), western Nepal

A Guide book on Geological Section of Bhupi-Sherchan Marg (Pokhara-Beni Highway), western Nepal

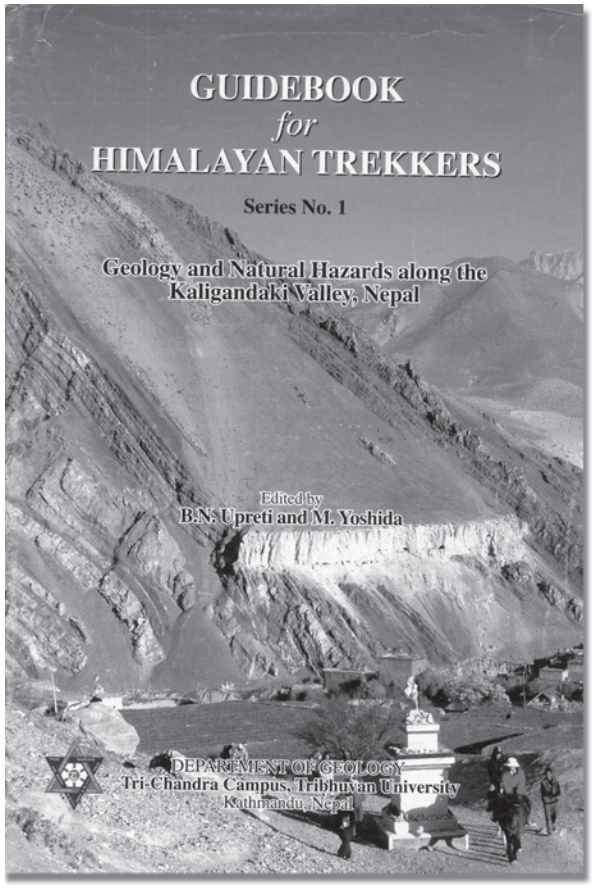

Fig. 2: A field excursion guidebook of Kaligandaki Valley published by the Department of Geology, Tri-Chandra Campus, Tribhuvan University (2005)

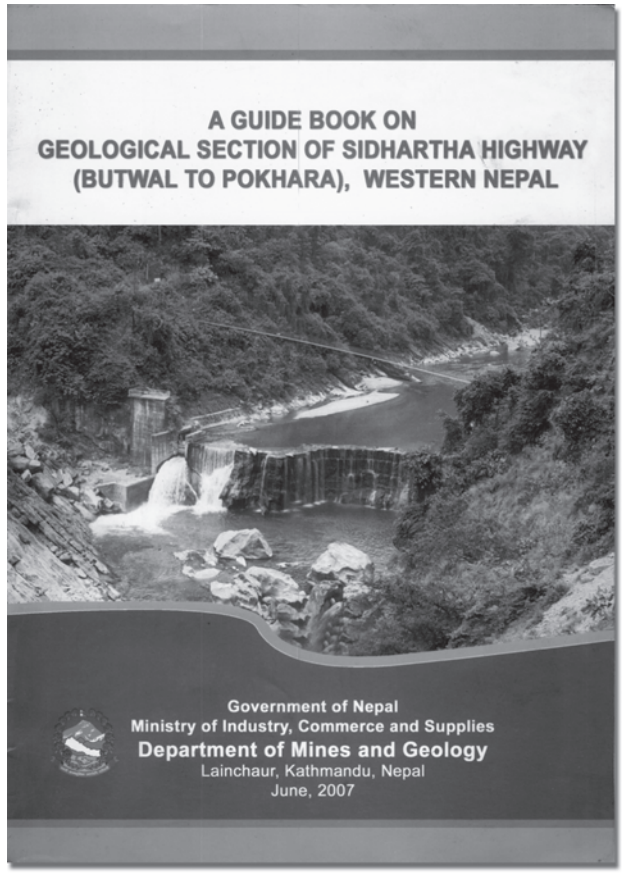

Fig. 3: A guide book on geological section of Sidhartha Highway published by the Department of Mines and Geology, Government of Nepal (2007)

was published by the Department of Mines and Geology, Government of Nepal in 2008 (Pradhanaga and Dhakal 2008; Fig. 4). The major content of this guidebook is mainly divided into: (i) general geology of Nepal, (ii) geology, geomorphology and natural hazards of the area (Beni to Pokhara), (iii) geology along the Highway, and (iv) geology or natural hazards outcrop (spot) description.

Arniko Highway, Kathmandu-Tatopani area, central Nepal

A *guide book in Geological Section along Arniko Highway (Kathmandu - Kodari Road), Central Nepal* was published in 2006 (Pradhanaga and Duvadi 2006; Fig. 5). This guidebook was published by the Department of Mines and Geology, Government of Nepal. The content of this guidebook is mainly divided into: (i) general geology of Nepal, (ii) geomorphology, natural hazards and geology of the Kathmandu-Kodari area, (iii) geology along the Arniko Highway, and (iv) outcrop (spot) description on the route.

Langtang Valley, central Nepal

A Japanese version, *Geology and Natural Hazards along the Langtang Valley, central Nepal Himalaya* was published in October 2008 as the Miscellaneous Publication No. 19 of the Gondwana Institute for Geology and Environment (GIGE), Japan (Yoshida et al. 2008a; Fig. 6). This Japanese publication forms a precursor of the *Guidebook for Himalayan Trekkers Series No. 3: Geology and Natural Hazards along the Langtang Valley, Nepal Himalaya* by the Department of Geology, Tri-Chandra Campus, Tribhuvan University and it is under the editing for publication. The published Japanese guidebook mentioned above followed the same book style and contents to those of the guidebook of the Kaligandaki Valley.

Everest Region, eastern Nepal

A *Guidebook for Himalayan Trekkers Series No. 2: Eco-trekking in the Everest Region, Eastern Nepal (Geology and Environment along the Lukla-Everest Base Camp and Namche-Gokyo Route)* was recently published in 2011 (Yoshida et al. 2011; Fig. 7). This guidebook was published by the Department of Geology, Tri-Chandra Campus, Tribhuvan University in collaboration with the Gondwana Institute for Geology and Environment, Japan. Before publication of this guidebook, a Japanese version *Geology and Natural Hazards along the Dudhkoshi*

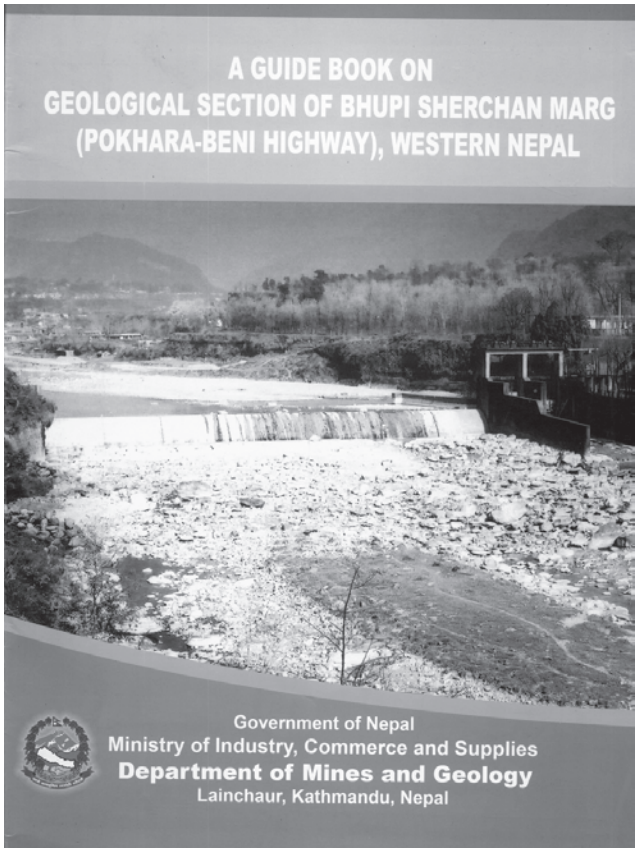

Fig. 4: A guide book on geological section of Pokhara-Beni Highway published by the Department of Mines and Geology, Government of Nepal (2008)

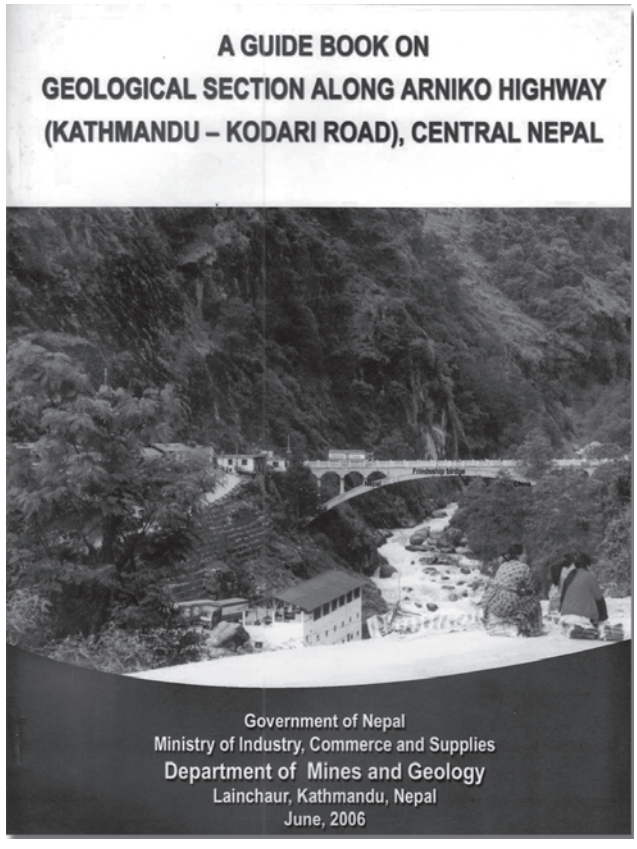

Fig. 5: A guide book on geological section of Arniko Highway published by the Department of Mines and Geology, Government of Nepal (2006)

Valley, Everest Area, Miscellaneous Publication No. 18, was published in 2007 by the Gondwana Institute for Geology and Environment, Japan (Yoshida et al. 2007).

This *Guidebook for Himalayan Trekkers Series No. 2* follows by the same style of presentation written in the *Guidebook for Himalayan Trekkers Series No. 1* (Kaligandaki Valley). This book is divided into main three parts: (i) introduction of the Himalaya, (ii) general geology, natural hazards and vegetation of the Everest area and (iii) field observation along the Everest trekking routes including the geology, natural hazards, and vegetation with natural beauty.

ADVERTIZEMENT AND UTILIZATION OF THE GUIDEBOOKS

These published guidebook series have been introduced in different national and international academic conferences/symposiums (Yoshida and Upreti 2004; Dahal and Yoshida 2006; Yoshida et al. 2006; Upreti et al. 2006, Rai et al. 2006; Dahal and Hasegawa 2007, Rai et al. 2007, 2008; Yoshida et al. 2008b, c, d; Upreti et al. 2010). The *Guidebook for Himalayan Trekkers, Series No. 1: Geology and Natural Hazards along the Kaligandaki Valley, Nepal* is available on the websites of the Gondwana Institute for Geology and Environment (GIGE), Japan (http://www.geocities.jp/gondwaninst/Yoshida/guidebookadv.pdf). These different guidebooks are used in different field excursions organized by professional organizations. Scientists, engineers, teachers, students and trekkers are regularly using these guidebooks.

FUTURE PLANS FOR PUBLICATION

The Department of Geology, Tri-Chandra Campus, Tribhuvan University is planning to publish *Guidebook for Himalayan Trekkers Series No. 3: Geology and Natural Hazards along the Langtang Valley, Nepal Himalaya* in near future and it is under the preparation for publication. The department has carried out the field observations around Kathmandu Valley, Malekhu area and Butwal-Tansen area for future successive series of the guidebook.

CONCLUSIONS

Field excursion guidebooks (English and Japanese versions) have been published for different regions of Nepal:

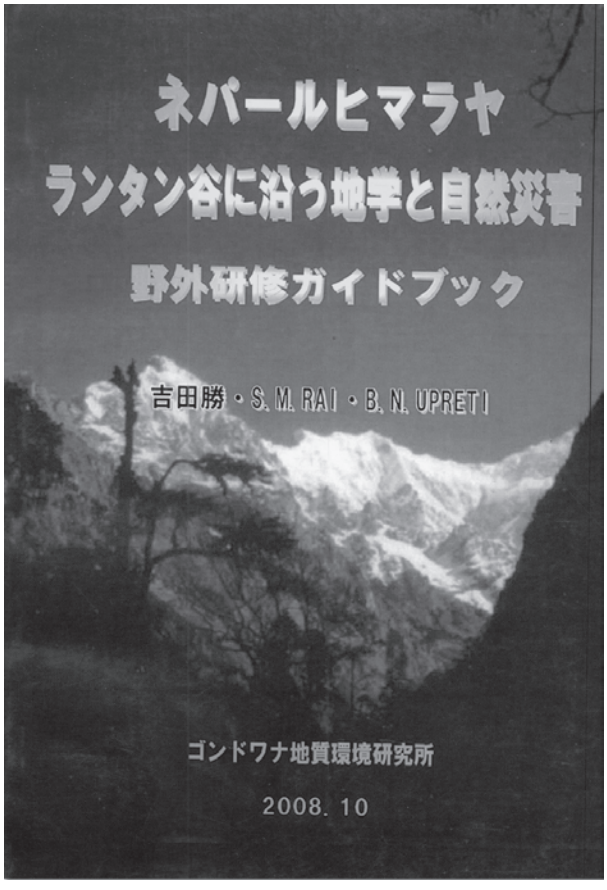

Fig. 6: A field excursion guidebook of Langtang Valley published by the Gondwana Institute for Geology and Environment (GIGE), Japan, 2008 (Japanese version)

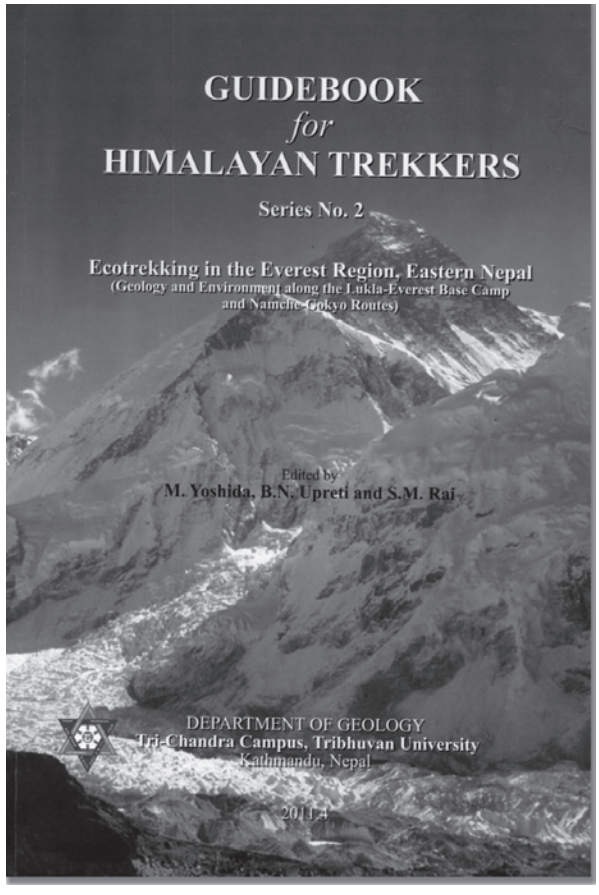

Fig. 7: A field excursion guidebook of Everest Region published by the Department of Geology, Tri-Chandra Campus, Tribhuvan University, 2011

Kaligandaki Valley and Sidhartha Highway (western Nepal), Langtang Valley and Arniko Highway (central Nepal) and Dudhkoshi Valley, Everest area (eastern Nepal). These guidebooks can help national or international scientists, engineers, teachers, students, planners, mountaineers, trekkers or social workers, governmental and nongovernmental organizations to collect the information on natural environments especially on geology, natural hazards and vegetations. These guidebooks also will be very useful to make new projects on the area. Eco-tourism of the Himalaya will be developed by the tourists using these guidebooks each year. A regular plan to publish successively such a type of excursion guidebook is going on recently by the Department of Geology, Tri-Chandra Campus, Tribhuvan University, Nepal.

ACKNOWLEDGEMENTS

The authors express their sincere thanks to the Japan International Cooperation Agency (JICA), Nepal for supporting a considerable part of expenses for the field studies in Kaligandaki Valley and the Everest region and financial support for publication of the Guidebook for Trekkers Series 1. The authors are also thankful to the Gondwana Institute for Geology and Environment, Japan for field expenses of the Everest region and Langtang Valley and partial financial support for publication of the Guidebook for Trekkers Series 2. The authors are indebted to the Department of National Park, Government of Nepal, Babar Mahal, Kathmandu for providing the permission to conduct the geological and botanical field surveys.

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What does the Lake Aoki sediment record tell about its origin?

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ABSTRACT

A 15 m long sediment core extracted from the sub-basin of Lake Aoki located in central Japan was investigated for its lithology and sedimentary features to understand the timing and origin of the lake. Terminated on matrix supported gravel bed, the lithology of the core sediment is dominated by silty clay with occasional intercalations of fine silt and both graded (turbidites) and none graded sand layers. The sediment also contained eight visible volcanic ashes and one scoria layers and some convolution features. Both the turbidities and convolutions are interpreted as earthquake induced features. Sediment chronology was derived from three volcanic tephra and two radiocarbon dates, which placed the bottom sediment age at 43 ka cal BP. Since the core is terminated on basement gravel, the bottom sediment age, i.e. 43 ka cal BP is interpreted as the time of formation of Lake Aoki. The mechanism that gave birth to the lake is most likely to be an earthquake induced landslide damming of the preexisting stream in the Omachi valley. Presence of collapsed deposit and old landslide scars in the catchment area combined with the presence of basement gravel bed at the core bottom itself and the passage of Itoigawa-Sizuoka Tectonic Line along the valley are some of the clues to support the proposed formation mechanism.

Keywords: Lake Aoki, matrix supported gravel, turbidite, convolution, sediment chronology, volcanic tephra

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INTRODUCTION

Study area

As in other parts of the world, lakes have a wide range of geographical and environmental distribution in Japan, and they come on a large selection of sizes, depths, chemistries, salinity, and origins. A narrow intermontane valley extending N-S from Hakuba to Omachi City, near the northern Japanese Alps, central Japan hosts a series of three fresh-water bodies, viz Lake Aoki, Lake Nakatsuna and Lake Kizaki, which are known by the "Nishina Three Lakes" (Fig.1). Lake Aoki, the study area, is located at an elevation of 822 m as the headwater source of the other two lakes in the south has a maximum length and width of 1.7 km and 1.4 km, respectively, and has a perimeter of 6.5 km (Figs. 1 and 2). It is intermediate in size (1.86 km^2), but the deepest (58 m) and largest water body among the three lakes (Adhikari et al. 2002). The lake has topographic closures in the east, west and north, and draws runoff from 9.2 km^2 area. The peak elevation in the catchment area is about 1599 m with a maximum relief of 778 m.

Beginning of limnological studies of Lake Aoki dates back to 1907 with the works of Tanaka (1930). Sediment investigation in this lake started in 1987 when the geological Survey of Japan (Inouchi et al. 1987) extracted two sediment cores (17 and 28 m) and made some lithologic description. Further studies on these sediments were limited to the grain-size analysis of the longer core from which several turbidite horizons were reported in the early history of the lake (Manaka et al. 1998), and age of the lake is estimated to be about 30 ka BP. In separate study of Late Quaternary sediment around Lake Aoki, Ono et al. (2000) discussed the inception mechanism and age of Lake Aoki. But, lack of dated horizons in the lower part of the core made the precise age determination of the core bottom difficult. Later, Adhikari et al. (2002) reconstructed the climatic history of the last 10 ka from a separate short core taken from Lake Aoki.

However, long-term climatic reconstruction and precise timing of formation of the lake has not yet been well-known from the sediment of this lake although more dating in combination with detail lithologic study of the available cores could reveal that information. In this study an attempt is made to investigate timing and mechanism of formation of the lake through the study of lithology and sedimentary features and dating of the 17 m long core sediment.

Bathymetry

Bathymetry of Lake Aoki defines a main basin and a hanging sub-basin which are separated by a steep slope (Fig. 2). The main basin has roughly a rectangular outline and reaches a maximum depth of about 58 m at two depressions. It is symmetrically bounded by a steep bathymetric gradient to the north, south and west in the upper slope and a gentle slope merged to the basin plain in the foot slope (Fig. 2). This gentle foot slope is wider in the axial ends of the basin than in the other two sides. The eastern one third part of the lake appears gently sloping westward with a narrow flat area

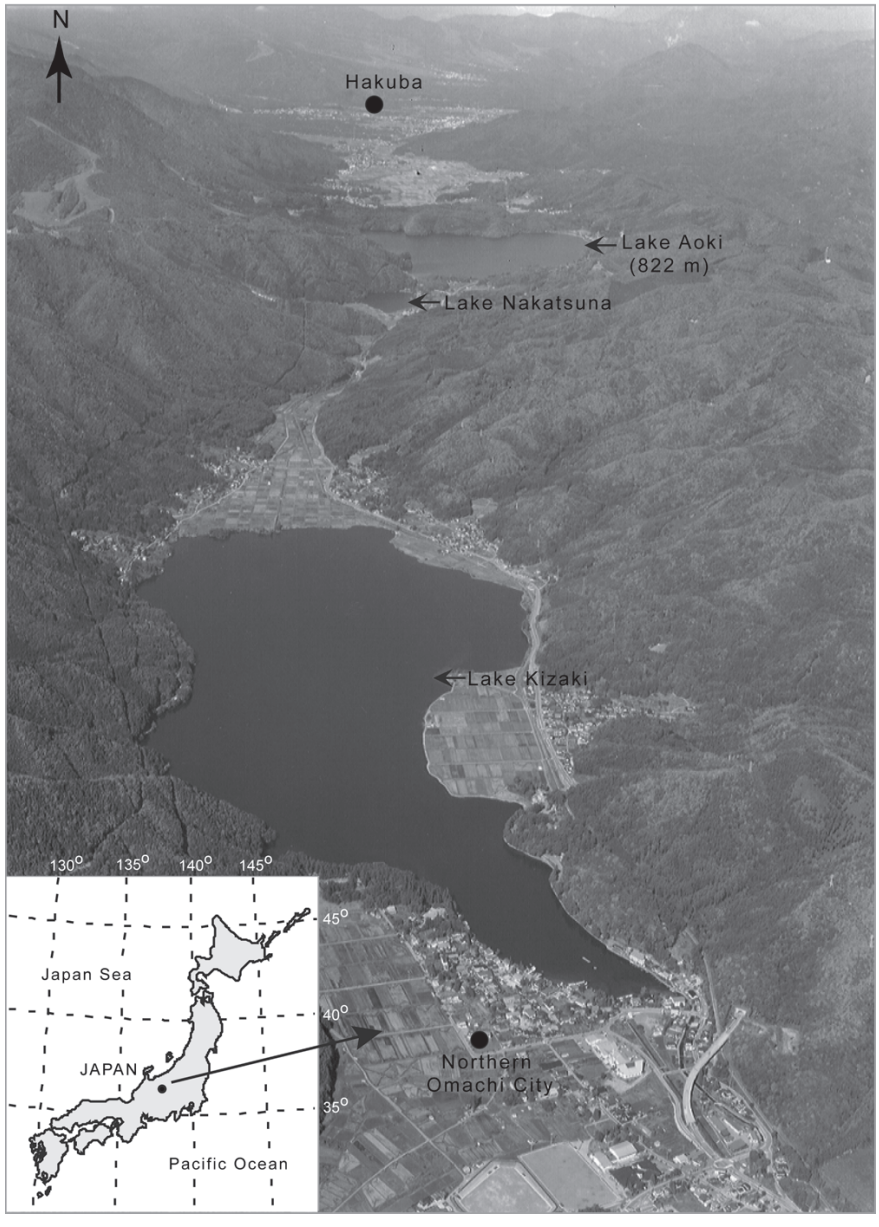

Fig. 1: Location and aerial view of Nishina Three Lakes, Lake Aoki, Lake Nakatsuna, and Lake Kizaki. The Itoigawa-Sizuoka Tectonic Line runs through this valley. (Photograph: courtesy of H. Hayasi 2000)

lying under the water depth of about 32.5 m and abutting one of the bathymetric highs in the south, above the main basin. This is the sub-basin that is bounded by steep gradient to the east and south, and gentle slope to the north (Fig. 2).

Geology

Bedrock units in the western part of the catchment area consist of Cretaceous granite and welded tuffs, and that in the eastern part are Tertiary sedimentary rocks (Omine Formation) and Quaternary terrace deposits (Kosaka 1983). Mountain located in the northern part of the basin (Sanozakayama) [Figs. 1 and 2] consists of collapsed deposits (Yamasita et al. 1985). Geology of the drainage basin is well reflected in its morphology as high relief and steep slopes prevail to the west, while low-lying gentle topography predominates to the east (Fig. 1). The Itoigawa-Shizuoka Tectonic Line (ISTL), a well-known boundary fault, runs through this valley and the formation of the 'Nishina Three Lakes' may have a genetic relation with this active fault system.

Hydrology

With an average depth of 29 m and water residence period of about 193 days, Lake Aoki is the largest water body (53940×10^3 m^3) among the Nishina Three Lakes (Tanaka 1930). Despite its large dimension, streams

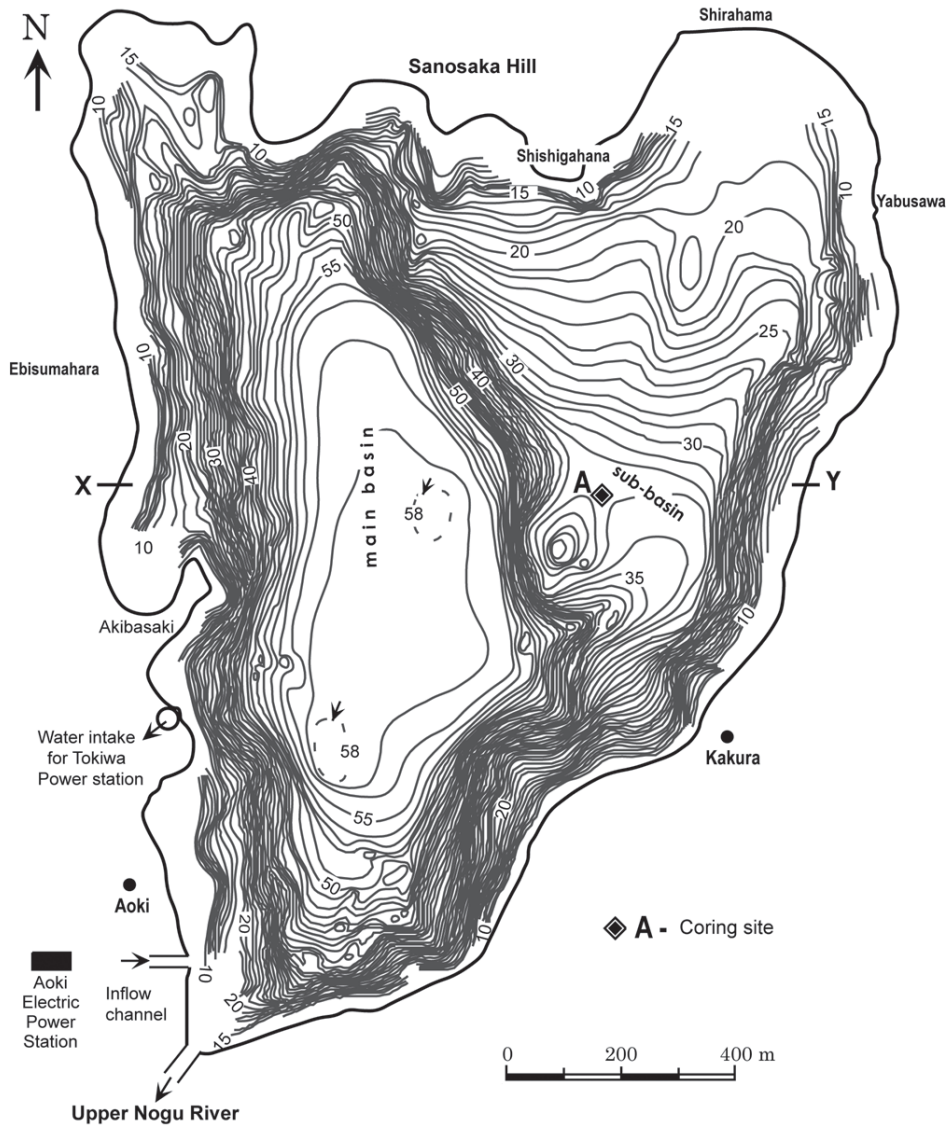

Fig. 2: Bathymetric features of Lake Aoki and the location of coring site. Contours are at 1 m interval. Bathymetric map is modified after Inouchi et al. (1987).

draining the catchment are few and small, and hence no specific names are given. Amount of natural inflow is estimated at 0.58 m^3s^{-1} (Watanabe et al. 1987). Since 1954, an artificial flow supplied from a tributary of Kashima River for electric power generation at Aoki power station joins into the lake at its southern extremity close to the outlet sill. This is the largest flow entering the lake with an annual average flow of 2.69 m^3s^{-1} as of average of 1974 -1987 (Watanabe et al. 1987). Since that time, lake water has also started to be drained to Tokiwa Power Station through a tunnel for the same purpose (Fig. 2). This usage drops lake level during winter and early spring season, with a maximum of 20 m. Surface outflow from Lake Aoki flows into Lake Nakatsuna to the south through the Upper Nogu River (Figs. 1 and 2). Some of the geographical and limnological features of Lake Aoki and its surrounding area are summarized in Table 1.

The area is characterized by monsoon-type climate with cold dry winters and moist hot summers. The surrounding area experiences more than 1 m thick snowfall in winter and makes the mountain slopes suitable for skiing (Adhikari and Kumon 2001). During winter extremes, shallow peripheral part of the lake undergoes ice bounding for a few weeks, but the inner lake surface rarely freezes.

METHODOLOGY

The 17 m long core sediment previously extracted by the Geological Survey of Japan (Inouchi et al. 1987) from the deepest part of the sub-basin of Lake Aoki under the water depth of 32.5 m (Fig. 2) was the material of this study. Sediment core was recovered and split lengthwise in the laboratory. Lithology was described on the cut surface; colors were assigned using Munsell soil color charts, and

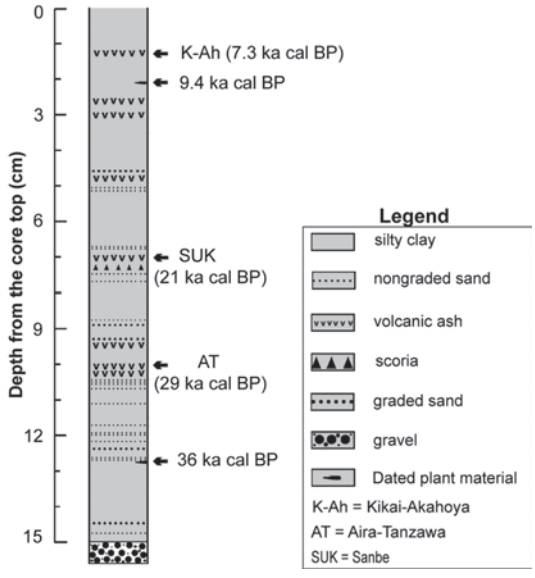

Fig. 3: Lithologic column of the cored sediment along with the dated horizons and their ages.

Table 1: Summary of the geographical and limnological features of Lake Aoki

Lake Aoki	
Latitude and longitude	36° 36' 32" N 137° 51' 14" E
Mean annual temperature (°C)	9.4
Mean annual precipitation (mm)	2022
Surface elevation (m)-	822
Drainage basin area (km^2)	9.2
Maximum relied in the drainage basin (m)	778
Perimeter (km)	6.5
Maximum depth (m)	58
Average depth (m)	29
Volume (x 10^3 m^3)	53940
Water residence period (days)	193
Lake type	oligotrophic

Note:Location as well as lake and catchment characteristics were determined from topographic and bathymetric maps, and partly referred from Saijo (2001) and Horie (1962).

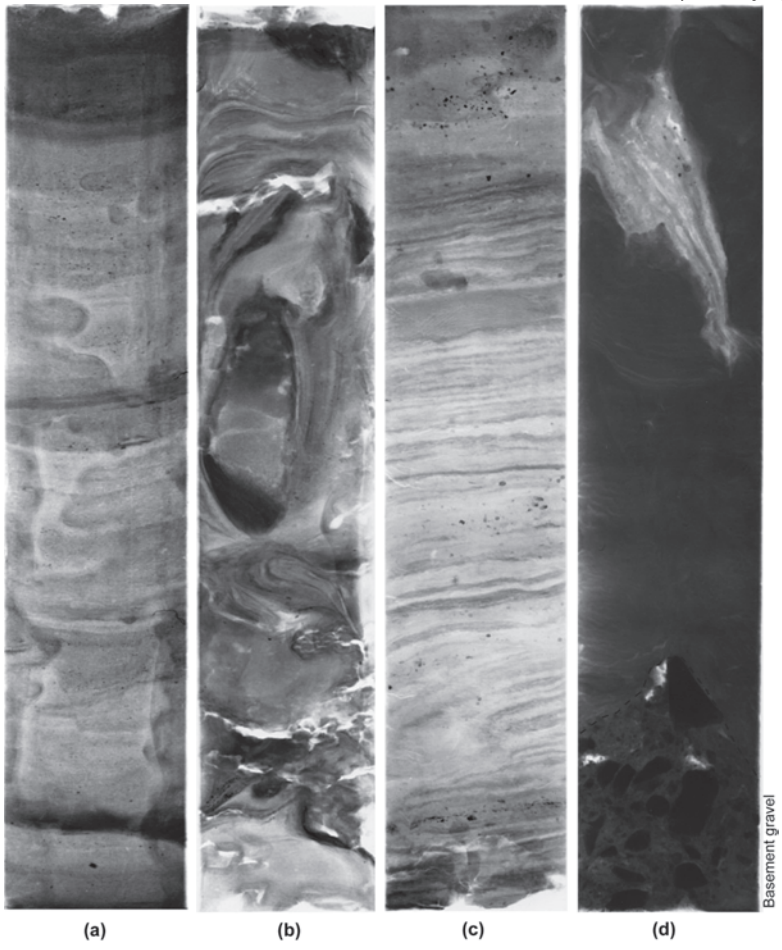

Fig. 4: X-Ray photographs of selected parts of the core sediment with: (a) Fine sedimentary layers and some turbiditie horizons; (b) Convolution - soft state deformation; (c) Varve with light and dark sedimentary layers, and (d) Basement gravel and the overlying massive sediments.

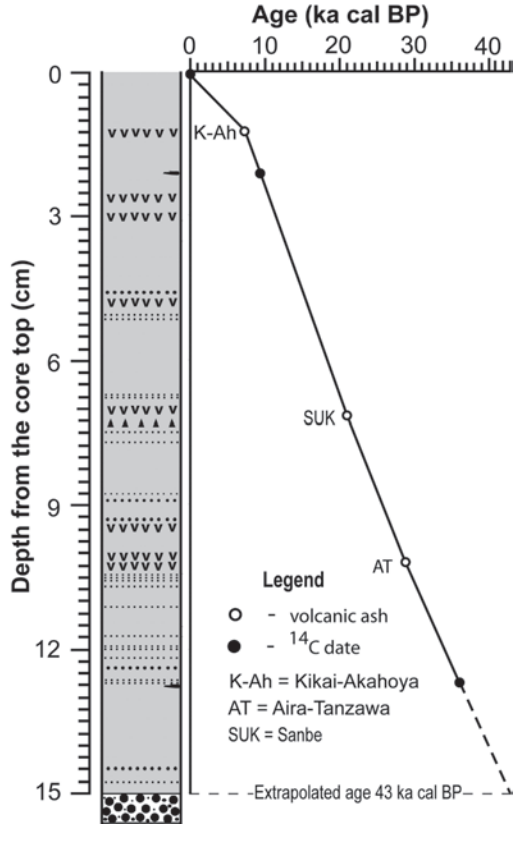

Fig. 5: Age-depth relationship of the sediments and estimation of the core bottom age.

X-rayed to reveal internal sedimentary features. Although the core was initially 17 m long, observation of the sediment in laboratory revealed about 2 m slim materials, and by removing that portion of the sediment, the true length of the core became 15 m. All the depths mentioned in this paper are the depth adjusted for the 15 m long core.

Volcanic glasses from three ash-fall horizons, 1.24-1.25 cm, 7.15-7.16 m, and 10.21-10.22 m, were extracted, cleaned, and observed under the microscope to determine the mineral composition, refractive index and morphology of the glass shards. Then the volcanic ash layers were correlated to the known widespread tephra based on the microscopic features and their stratigraphic position. Radiocarbon dating of the sediments was performed for two plant materials taken from 2.10 cm 12.71 m using a standard Accelerator Mass Spectrometer (AMS). Sediment chronology was derived from the three volcanic ash and two radiocarbon dates and the ages were calibrated to calendar years using INTCAL09 (Reimer et al. 2009) and INTCAL98 (Stuiver et al. 1998). Age of the lake sediment at the core bottom was derived by extrapolating the overlying known age and the timing of formation of the lake was estimated.

RESULTS AND DISCUSSIONS

Lithology

The lithology of the core sediment is dominated by silty clay occurring in varieties of colors (e.g. dusky yellowish black, olive black, olive gray, greenish gray, greenish black) with occasional intercalation of fine silt and both graded and none graded sand layers (Fig. 3). These layers are more common at depths below 6 m and rare or absent above this level. The graded sand layers are fining upward and suggestive of turbidities deposit (induced from stream flood and/or subaqueous slumping from side slopes). Such type of deposit was previously reported in Lake Kizaki (Kumon 2000). Sediments are well laminated in the intervals between 4.2 and 5.2, 6.15 and 7.9, 8.2 and 9.5, 10 and 12, and 13.25 and 14.25 m, although some structureless intervals or less frequent lamina are also appeared within these intervals. Sediments above 4.5 m have no layers or lamina. These features were observed under both visual inspections (summarized in Fig. 3) and X-ray photographs (Fig. 4).

The bottom 55 cm of the core sediment is massive without any lamina (Fig. 4d) but the overlying interval between 13.55 and 14.45 m constitutes alternate light and dark, varve like bands in a semi-regular spacing (Fig. 4c). Some intervals such as between 8.71 and 9.2 and 11 and 11.5 are composed of nonlaminated soft mud with involutions (Fig. 4b). In some horizons, fragments of terrestrial leaf and wood are also observed. Based on X-ray photographs, sediments sometimes contained randomly distributed granule and sand-size particles (Fig. 5a), but varied among horizons. The important feature of the core is that it is terminated on matrix supported angular gravel bed (Fig. 5d), which is believed to represent the basement of the lacustrine sediment.

Moreover, the sediment also contained eight visually observed volcanic ash layers at different levels (Fig. 2), the thickness of which ranged from 2 mm to 1 cm and two of them were coarse enough to be seen the larger grains. In addition to the ash layers, a 2 cm thick scoria layer is also intercalated at 7.14 m. The ash layers were of ash gray colored with sharp lower boundary and diffuse upper boundary. They were steaky and very hard upon drying.

Tephra identification

The volcanic tephra layer intercalated at 1.24-1.25 m has vitric light brown appearance, and sugary texture. Its grain-size ranges from coarse silt to sand grade and composed of bubble-wall type glass shards with refractive index in the range of 1.511-1.513. Mineral phases are mainly orthopyroxene and clinopyroxenes. Based on the microscopic features and stratigraphic position, this ash is correlated with the widespread ash, Kikai-Akahoya (K-Ah), erupted from Kikai caldera, south Kyushu at around 7.30 ka cal BP (Machida and Arai 1992).

The tephra layer intercalated at 10.21-10.22 m is also a vitric ash with grading (coarse to fine) structure. This ahs is mainly composed of transparent bubble-wall type glass shards with refractive index in the range from 1.499-1.501, and the mineral composition includes orthopyroxene, clinopyroxene and some biotite. It is correlated with the Aira-Tanzawa (AT) volcanic ash which erupted from the Aira Caldera, southern Kyushu at about 29 ka cal BP (Machida and Arai, 1992). The third tephra layer intercalated at 7.15 m and is correlated as Sanbe (SUK) volcanic ash that erupted in Kyushu, Japan around 21 ka cal BP (Machida and Arai 1992).

The deposition of K-Ah, SUK and AT tephra layers represent time markers and have important implication for this study in respect to chronology. The radio carbon dating of the plant materials at 2.10 m and 12.17 m depths yielded calibrated age of 9.40 ka cal BP and 36 ka cal BP, respectively.

Chronology and sedimentary history

Since the Japanese Archipelago has a well known history of volcanic activities, identification and characterization of volcanic ash layers thereby provide chronological precision. The volcanic ashes identified as K-Ah, SUK, and AT with their corresponding reported ages, 7.3 ka cal BP, 21 ka cal BP, and 25 ka cal BP, and the two ^{14}C ages of the plant materials, 9.4 ka cal BP at 2.1 m and 36 ka cal BP at 12.71 m depths, are almost fall on a line (Fig. 5). These five ages therefore provide an excellent chronology of the sediment core. Considering continuation of the same sedimentation rate further down, the age at 12.71 m depth is extrapolated down to 15 m, and that placed the bottom sediment age at 43 ka cal BP (Fig. 5). Since the core is terminated on the basement gravel - a well cemented none lacustrine deposit, the bottom age, 43 ka cal BP is interpreted as the time of formation of Lake Aoki.

The angularity of the clasts in the basement gravel as evident in Fig. 4d clearly indicates none fluvial origin of the gravel bed. The presence of old landslide scars on the mountain slopes (Fig. 1) and collapsed deposit (gravel bed) on the surface in the northern part of the lake catchment (Yamashita et al. 1985), and the occurrence of similar material at the core bottom are suggestive of big mountain collapse event, which might have dammed the preexisting river in the valley and formed Lake Aoki sometimes around 43 ka cal BP. Sediment core penetrating further down from the basement gravel is expected to reach to the fluvial material. The passage of the Itoigawa-Sizuoka Tectonic Line along the valley also supports the possibility of occurrence of earthquakes, which triggered big landslide, dammed the valley, and gave birth to Lake Aoki.

CONCLUSIONS

The 15 m long sediment core taken from the sub-basin of Lake Aoki yields a complete record of lacustrine sedimentation with some intercalations of volcanic ashes and scoria layers and turbidites and convoluted intervals. The history of lake began when the lake first filled with water around 43 ka cal BP in response to landslide damming across the preexisting stream course. The finding of termination of the sediment core at matrix supported gravel bed in one hand, and the occurrence of collapsed deposits and old landslide scars in the catchment area and the passage of the Itoigawa-Sizuoka tectonic line through the valley in other hand are the sedimentological, geomorphic, and geological clues helpful to understand the basin closure mechanism. The occurrence of volcanic ash and scoria layers and the turbidites and convolution features in the sediment indicate that the last 43 ka was time of volcanic and earthquake activities in the region.

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अन्तर्विषयक अध्ययन : नेपालमा पुरापरागको अनुसन्धान र यसको महत्व

खुमनारायण पौड्याल

भूगर्भविज्ञान केन्द्रीय विभाग, त्रिभुवन विश्वविद्यालय, कीर्तिपुर, काठमाडौँ ।

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सारांस

विश्वभरि जलवायु परिवर्तन अध्ययनअनुसन्धानका क्रममा व्यापक रूपमा पुरापरागको अध्ययन भइरहेको छ । नेपालको काठमाडौँ उपत्यकामा नरम चट्टानहरूमा रहेका पुरापरागको माध्यमबाट जलवायु परिवर्तनसम्बन्धी केही शोधहरू भए पनि यससम्बन्धी अध्ययनले अपेक्षित गति लिन सकेको देखिदैन । पुरापरागको अध्ययनबाट प्रागभूगोल (paleogeography), प्रागवनस्पति (paleovegetation), प्रागपारिस्थितिकी (paleoecology) र प्रागवातावरण (palaeoenvironment) को विकास, विविधता र विस्तार पत्ता लगाउन सकिन्छ । यस लेखमा पराग अध्ययनको क्षेत्र, विधि, उपयोगिता र महत्वका बारेमा जानकारी दिने प्रयास गरिएको छ ।

१. विषयप्रवेश

वनस्पतिमा पाइने परागकणको (pollen and spores) अध्ययनलाई परागविज्ञान (palynology) भनिन्छ । भूगर्भ विज्ञानमा अन्य जीवाश्म (जीवावशेष) को अध्ययन सँगै परागकणका जीवाश्मको अध्ययनले विशेष महत्व राख्दछ । परागकणका जीवाश्म अर्थात् पुरापराग (fossil pollen and spores) को अध्ययनलाई पुरापरागविज्ञान (paleopalynology) पनि भनिन्छ । पुरापरागविज्ञान एउटा अन्तर्विषयक विधा हो । यसले भूगर्भ विज्ञान (geology) का साथै वनस्पति विज्ञान (botany) को समेत विशुद ज्ञानको अपेक्षा राख्दछ ।

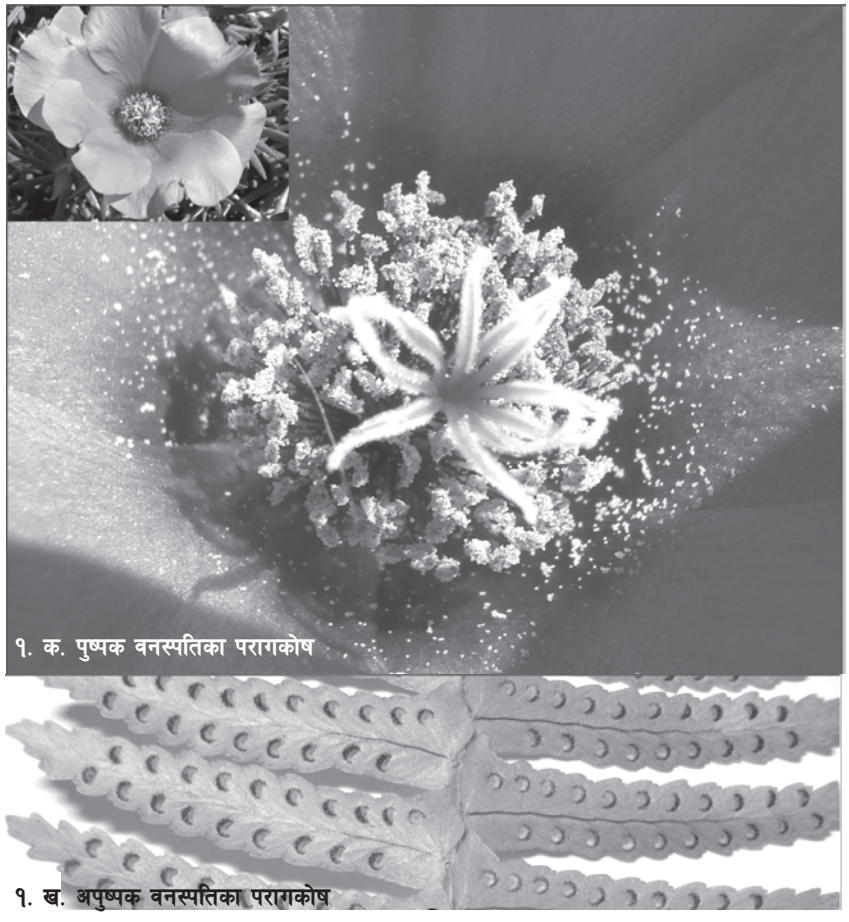
सरल भाषामा परागकणलाई पुष्पवीर्य भन्न सकिन्छ । अपुष्पक (cryptogames) र पुष्पक (phanerogames) दुवै थरि वनस्पतिले परागकणहरू उत्पादन गर्दछन् । अपुष्पक वनस्पतिले पातको तल्लो भागमा रहेका ससाना परागकोषहरू (sori) भित्र परागहरू (spores) उत्पन्न गर्छन् भने पुष्पक वनस्पतिहरूले फूलमा रहेको पुरुष जननाङ्ग (androecium) को टुप्पामा अवस्थित परागकोष (anther) मा परागहरू (pollen) उत्पादन गर्दछन् (चित्र नं. १) । परागकणको मुख्य कर्म गर्भाधान अर्थात परागसेचन हो । परागसेचनका लागि परागहरू स्त्रीपुष्पको जननाङ्ग (gynoecium) सम्म पुग्न आवश्यक छ । हावा, पानी, कीराफट्याङ्ग्रा, चराचुरुङ्गी अथवा अन्य प्राणीहरूका माध्यमबाट परागकणहरू स्त्रीपुष्पको संसर्गमा पुग्छन् र परागसेचन कार्य सम्पन्न हुन्छ । हावा, पानी र प्राणीद्वारा परागसेचन हुने वनस्पतिहरूलाई क्रमस एनेमोफिलस (anemophilous), हाइड्रोफिलस (hydrophilous), जुफिलस (zoophilous) वर्गमा विभाजन गरिएको छ । सारांसमा भन्नु पर्दा स्त्रीपुष्पमा अवस्थित डिम्ब (Ovum) को न्युक्लियससँग परागकणको न्युक्लियसको मिलनलाई गर्भाधान (fertilization) भनिन्छ । गर्भाधानपछि उक्त डिम्ब फलका रूपमा बृद्धि हुन थाल्दछ ।

यौनको सन्दर्भमा वनस्पतिहरू मानवभन्दा कामुक छन् । तर उनीहरूको कामुकता मनोरञ्जनका लागि भन्दा पनि सन्तानोत्पादनमा केन्द्रित छ । विशेष रूपमा पतझड वनस्पतिहरू यस मामलामा अगाडि देखिन्छन् । आरूको वृक्षको कल्पना गरौँ ! पतझडपछि आरूले पात निस्कनुपूर्व नै पुष्पवृष्टि सुरु गर्दछ । यसबाट पनि उनीहरूको सम्भोग प्रतिको लिप्सा प्रतीत हुन्छ । पात जीवनको प्रतीक हो किनभने पातबाटै वनस्पतिले खाद्यपदार्थ निर्माण गर्दछ तर उनीहरूलाई त पात पलाउनुप्रति रुचि नै छैन ! हाँगाहाँगा, डालीडालीमा जननेन्द्रीय प्रदर्शनमा रुचि छ । आरू, उत्तिस, भोजपत्रजस्ता वनस्पति अनेकौँ छन् जसले वसन्तको आगमनमा पालुवा निकाल्नुको सट्टा फूलका कोपिला उत्पन्न गर्दछन् । सन्तान उत्पादन र वंशवृद्धिका लागि यो उनीहरूको रणनीति पनि हो । सन्तानोत्पादनका लागि वनस्पतिलाई मानव वा अन्य जीवजन्तुको जस्तो सुविधा छैन । वनस्पतिहरू हिँडेर सम्भोगका लागि आफ्नो इच्छित जोडीसमक्ष पुग्न नसक्ने हुँदा उनीहरूले विशेष रणनीति बनाएका छन् । त्यही रणनीति अन्तर्गत स्त्री जननाङ्गसम्म आफ्ना परागहरू पुर्‍याउन उनीहरूले अत्याधिक मात्रामा पराग उत्पन्न गर्दछन् । अत्याधिक मात्रामा पराग उत्पन्न हुने हुँदा सबै परागकणहरूले परागसेचन गर्ने सौभाग्य प्राप्त गर्दैनन् । भोजपत्र *(Betula)*, उत्तिस *(Alnus)* जस्ता वनस्पतिको एउटा परागकोषमा १०,००० परागकण रहेका हुन्छन् । त्यस्तै तीतेपाती *(Artemisia)*, भाङ् *(Cannabis)* आदि वनस्पतिमा प्रति परागकोष ७०,००० परागकण पाइन्छन् (Fægri and Iversen 1989) । यस मामलामा सदाबहार प्रकृतिका सल्ला जातका वनस्पति अझ अगाडि छन् । रानीसल्ला *(Pinus)* को एउटा फूलमा मात्र ६,००,००० परागकण पाइन्छन् ।

परागसेचन गर्न नसकेका अभागी परागहरू हावामा तैरिदै नदी वा ताल आदिसम्म पुग्छन् र थेग्रिन थाल्दछन् । कतिपय परागकण भुईमा खस्छन् अनि वर्षाको पानीले बालुवा र माटोसँगै तिनीहरूलाई बगाएर नदी, ताल वा समुद्रसम्म पुऱ्याउँछ । त्यहाँ माटो बालुवासँगै तिनीहरूको थेग्रिने (sedimentation) र जीवाश्मीकरण (fossilization) प्रक्रिया प्रारम्भ हुन्छ र अन्त्यमा परागकणहरू जीवाश्मका रूपमा चट्टानमा सुरक्षित हुन पुग्दछन् (चित्र नं. २) ।

२. पृष्ठभूमि

परागकण अत्यन्त सूक्ष्म आकारका हुन्छन् । परागकणलाई वनस्पतिका औँलाको छाप (finger prints) पनि भन्न सकिन्छ । जसरी एउटा मान्छेको औँलाको छाप अर्को मान्छेसँग मिल्दैन त्यसरी नै वनस्पतिको एउटा प्रजातिको (species) परागकण अर्को प्रजातिसँग मेल खाँदैन । परागकणको आकारप्रकार र तिनीहरूको बनोटका आधारमा ती कुन प्रजातिका हुन पत्ता लगाउन सकिन्छ । प्रायः परागकणहरू गोलाकार वा वर्तुलाकार हुन्छन् । परागकणको व्यास १०

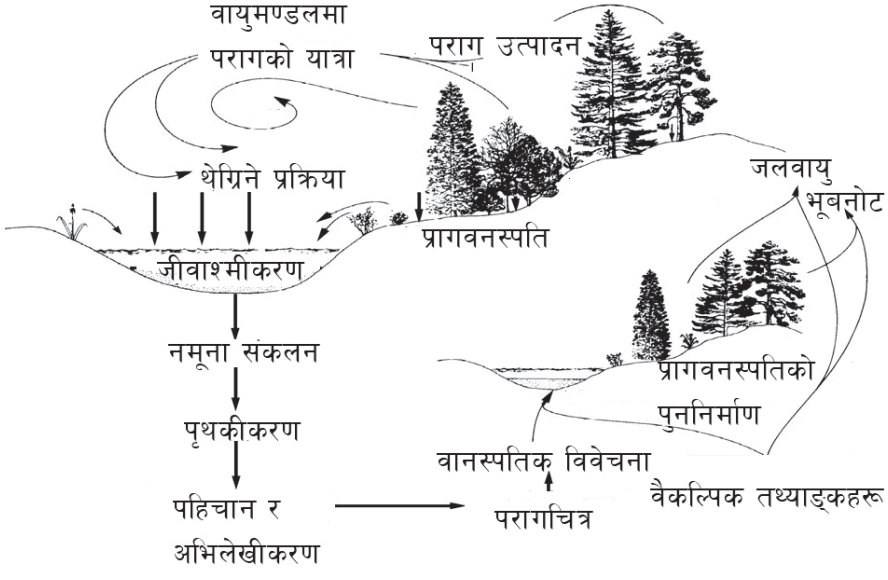


चित्र नं. १: पुष्पक र अपुष्पक वनस्पतिका परागकोष एवं पराग उत्पादन प्रक्रिया

देखि २०० माइक्रोनसम्म हुने हुनाले तिनीहरूलाई अध्ययन गर्न विशेष सूक्ष्मदर्शकयन्त्रको आवश्यकता पर्दछ । परागकणको अध्ययनको क्षेत्र पनि विविध छ । यसले विशुद्ध प्राज्ञिक अनुसन्धानदेखि मानवजीवनका दैनिकीहरूलाई समेत छोएको छ ।

विकसित देशहरूका कृषि वा खाद्यविज्ञान प्रयोगशालाहरूमा महको प्रकार एवम् गुणस्तर मापन गर्न महमा रहेका परागकण अध्ययन गरिन्छ । महमा रहेका परागकण अध्ययन गर्ने परागविज्ञानको शाखालाई मेलिसोप्यालिनोलोजी (melissopalynology) भनिन्छ (Jones et al. 1995) । कतिपय विषालु परागकण श्वासप्रश्वास सम्बन्धी रोगको कारण बन्दछन् । चिकित्साविज्ञानमा फोक्सो, आँखा, नाकसम्बन्धी एलर्जीको कारण पत्ता लगाउन वायुमण्डलमा रहेका यस्ता विषाक्त परागकणको अध्ययन गरिन्छ । यसलाई क्लिनिकल प्यालिनोलोजी (clinical palynology) भनिन्छ । विकसित देशहरूमा मौसमको भविष्यवाणी गरेजस्तै वायुमण्डलमा रहेका परागकणका बारेमा सूचना गरिन्छ । अचेल अपराधशास्त्रमासमेत प्यालिनोलोजीको प्रयोग गर्न थालिएको छ । अपराधीका जुत्ता–कपडामा पाइने परागकणको अध्ययनबाट अपराधीका गतिविधि पत्ता लगाउने प्यालिनोलोजीको अर्को प्रशाखालाई फरेन्सिक प्यालिनोलोजी (forensic palynology) भनिन्छ (Moore et al. 1991) । वनस्पति विज्ञानका अनुसन्धानहरूमा वनस्पति वर्गीकरण (taxonomy) का क्रममा आइपर्ने अप्ठेराहरूमा परागकणको अध्ययन निकै सहयोगी मानिन्छ । ऐतिहासिक स्थलहरूको पुरातात्विक अनुसन्धान गर्दा उक्त स्थानको माटोमा रहेका परागकणका जीवाश्मको अध्ययन गरिन्छ । मानव र वनस्पतिको अन्तरसम्बन्ध पत्ता लगाउन गरिने परागकणको यस्तो अध्ययनलाई आर्कियोप्यालिनोलोजी (archaeopalynology) भनिन्छ । भूगर्भविज्ञानमा पुरापरागको अध्ययन प्राणी र वनस्पतिका अन्य जीवाश्मजस्तै चट्टानहरूको अन्तरसम्बन्ध (correlation) र आयु पत्ता लगाउन गरिन्छ । यसका अतिरिक्त पृथ्वीमा विगतमा भएका जलवायु परिवर्तनको अनुसन्धान गर्न परागकणको अध्ययन अत्यन्त उपयागी साधन भएको छ । वनस्पतिहरू पारिस्थितिकी (ecology) प्रति अत्यन्त संवेदनशील हुन्छन् । पारिस्थिति प्रणाली (ecosystem) मा हुने ससानो परिवर्तनले पनि वनस्पतिको विविधता, विस्तार, विकासमा ठूलो असर पार्दछ । परागकणहरूको मद्दतले प्रागभूगोल (paleogeography), प्रागवनस्पति (paleovegetation), प्रागपारिस्थितिकी (paleoecology) र प्रागवातावरण (palaeoenvironment) को विकास, विविधता र विस्तार पत्ता लगाउन सकिन्छ ।

भौगर्भिक निक्षेपहरूबाट परागकणको अध्ययन गर्ने पहिलो वैज्ञानिक हन्–लेन्नार्ट भोन पोस्ट । स्विडेनका यी भूगर्भशास्त्रीले सन् १९१३ मा पुरापराग विश्लेषण गर्ने आङ्किक पद्धतिको आविष्कार गरेका थिए । उनलाई आधुनिक प्यालिनोलोजीका पिता पनि भनिन्छ । सन् १९२१ मा स्विडेनका अर्का वैज्ञानिक



चित्र नं. २: पुरापराग अध्ययनको आधारभूत सिद्धान्त

गुन्नार एर्टमानले 'पोलेन एनालाइसिस' नामक पुस्तक प्रकाशन गरे । यो पुस्तकको प्रकाशनपछि युरोप र अमेरिकामा क्वाटर्नरी समय (Quaternary Epoch) का चट्टानहरूमा रहेका पुरापराग अध्ययन गर्ने पद्धतिले लोकप्रियता प्राप्त गर्न थाल्यो । क्वाटर्नरी समयमा पटकपटक हिमप्रपातले थलिएको युरोप र उत्तरी अमेरिकाका वैज्ञानिकहरूलाई प्रागजलवायु परिवर्तन अध्ययन गर्ने एउटा भरपर्दो सूत्र प्राप्त भयो । विकिरण प्रणाली का आधारमा चट्टानहरूको आयु पत्ता लगाउने प्रविधिहरूको (radiometric dating) आविष्कारसँगै पुरापरागको अनुसन्धानले अझै उचाइ प्राप्त गऱ्यो (Traverse 1988) ।

३. नेपाली सन्दर्भ

विकसित देशहरूमा र छिमेकी देशहरूमा पुरापरागका आधारमा प्रागवातावरण अनुसन्धानमा व्यापक प्रयोगहरू भइरहँदा नेपालमा भूगर्भशास्त्रीहरू त्यस विषयमा प्रायः अनभिज्ञ नै थिए । अस्ट्रियाको भियनास्थित बोकु विश्वविद्यालयका प्राध्यापकद्वय फ्रान्ज र क्रालले सन् १९७५ मा काठमाडौं र जुम्लाबाट सङ्कलन गरिएका चट्टानमा रहेका पुरापराग अध्ययन गरेका थिए । नेपाली प्रागवातावरणको अनुसन्धानमा त्यो नै पहिलो पाइलो थियो । काठमाडौं प्रागपोखरीको कालोमाटोमा पाइएका पुरापरागको विविधताले हौसिएका क्रालले आफ्ना सहकर्मी हाभिङ्गासँग मिलेर सन् १९७९ मा अर्को अध्ययन गरे । उनका यी दुवै शोधका परिणामहरू अस्ट्रियन एकेडेमीको जर्नलमा जर्मन भाषामा प्रकाशित गरिएको थियो (Franz and Kral 1975; Kral and Havinga 1979) । सन् १९८४ मा भारतको लखनउ स्थित वीरबल साहनी इन्स्टिच्युट अफ प्यालेओबोटानीका वैज्ञानिकहरू विष्णु मित्र र छाया शर्माले मनोहरा नदी र ठिमी क्षेत्रका पुरापरागको अध्ययन गरे र उनीहरूले उक्त अनुसन्धानका परिणामहरू फ्रान्सबाट प्रकाशित हुने जर्नलमा प्रकाशित गरे (Vishnu Mittre and Chhaya Sharma 1984) । सन् १९८४ मा नै जापानका वैज्ञानिकहरू मित्सुयो योशिदा र येको इगाराशीले काठमाडौं र थाकखोला क्षेत्रका परागकणहरूको अध्ययन गरे । योशिदा र इगाराशीले काठमाडौं र थाकखोला उपत्यकाको भौगर्भिक नक्साङ्कन मात्र गरेनन् उनीहरूले आयुका आधारमा यहाँका चट्टानहरूलाई वर्गीकरणसमेत गरे । उनीहरूले आफ्ना शोधका नतिजाहरू नेपाल र भारतका जर्नलहरूमा प्रकाशित गरेका थिए (Yoshida and Igarashi 1984; Igarashi et al. 1988) । प्रागवातावरण अनुसन्धानका क्षेत्रमा यी सबै प्रारम्भिक अनुसन्धानहरू उत्साहजनक थिए ।

नेपालको भौगर्भिक अवस्थिति अनि प्रागवातावरण अनुसन्धानमा यहाँका चट्टानहरूमा सुरक्षित पुरापरागले दिने जानकारी अत्याधिक महत्वपूर्ण भएकाले यसको अध्ययनको परिधि अझै विस्तार हुन थाल्यो । यसैक्रममा सन् १९८९ मा भारतको लखनउ स्थित वीरबल साहनी इन्स्टिच्युट अफ प्यालेओबोटानीका वैज्ञानिक समीर सरकारले पश्चिम नेपालमा अवस्थित सुराइ खोला क्षेत्रमा सिवालिक पर्वत श्रृङ्खलाका परागकणहरू अध्ययन गरेर मायोसिन समयमा (Miocene Epoch) त्यस क्षेत्रमा भूमध्यरेखीय उष्ण जलवायु रहेको तथ्य प्राप्त गरे (Sarkar 1989) । अर्का जापानी वैज्ञानिक नाकागावाले सन् १९९६ मा काठमाडौंको गोकर्ण क्षेत्रका चट्टानमा पाइएका पुरापरागहरू अध्ययन गरे । उनले परागकणको पहिचान जटील भएकाले यसप्रकारको अनुसन्धानमा स्क्यानिङ इलेक्ट्रोन माइक्रोस्कोप (SEM) को व्यापक प्रयोग गर्नु पर्ने धारणा सार्वजनिक गरे (Nakagawa et al. 1996) । सन् १९९७ मा दुइ जापानी वैज्ञानिक योनेबायासी र मिनाकीले पूर्वी नेपालको करीब ४००० मीटर उचाइमा रहेको ठूलीपोखरीको पौंधबाट निकालिएका चट्टानहरूमा पुरापरागको अध्ययन गरे । उनीहरूको अनुसन्धान होलोसिन समय (Holocene Epoch) मा केन्द्रीत थियो । उनीहरूले ७५० देखि ११००० वर्षसम्मको प्रागवातावरण पत्ता लगाएका थिए (Yonebayashi and Minaki 1997) । सन् २००० मा नेदरल्यान्डकी वैज्ञानिक क्यारिना हुर्नको टोलीले सिवालिक पर्वतमालाका पुरापरागको अध्ययन श्रृङ्खला अझ अगाडि बढायो । दुई जना अमेरिकी वैज्ञानिकसमेत सम्मिलित उक्त टोलीले सुराइ खोलाका चट्टानमा पुनः अनुसन्धान गऱ्यो र समीर सरकारकै अनुसन्धानलाई पुष्टि गर्ने परिणामहरू प्राप्त गऱ्यो (Hoorn at al. 2000) । वातावरण अनुसन्धानकै क्रममा जापान स्थित क्युसु विश्वविद्यालयको टोलीले काठमाडौं उपत्यकाका विभिन्न स्थानमा २८४ मिटरसम्म गहिरा इनारहरू (drill hole) बनायो र त्यहाँबाट निकालिएका चट्टानहरूमा पुरापरागको अध्ययन गऱ्यो । हारुताका साकाइको नेतृत्वमा भएको उक्त अनुसन्धानले काठमाडौं

उपत्यका वरपरको २५ लाख वर्ष पुराना वातावरणीय रहस्यहरूलाई उद्घाटन गर्न सफल भयो (Fujii and Sakai 2001; Fujii and Sakai 2002) । काठमाडौँ उपत्यका र सिवालिक पर्वतका चट्टानमा मात्र होइन उच्च पहाडी भागमा समानान्तर रूपमा प्रागवातावरणका अनुसन्धानहरू भइरहेका छन् । जर्मनीका वैज्ञानिकद्वय फ्रान्ज स्लुत्स र उल्फगाङ्ग जेखले गोर्खा जिल्लामा ३५०० मिटर उचाइमा अवस्थित रुक्चे तालका पीँधका चट्टानहरूको अध्ययन गरेर १००० देखि १५००० वर्ष अगाडि सम्मको प्रागवातावरण प्रकासमा ल्याएका छन् (Schluez and Zech 2004) । पछिल्लो समयमा विदेशी वैज्ञानिकका अतिरिक्त प्रागवातावरण अध्ययनको यो क्रमलाई त्रिभुवन विश्वविद्यालय, भूगर्भविज्ञान केन्द्रीय विभागका वैज्ञानिकहरूले पनि अगाडि बढाएको देखिन्छ (Paudayal and Ferguson 2004; Paudayal 2005; Paudayal 2006; Bhandari and Paudayal 2007) ।

४. अध्ययन प्रक्रिया

४.क. नमूना सङ्कलन

पुरापराग प्रायः मसिना कणहरू (fine grained) बाट बनेका पत्रे चट्टानहरू जस्तै क्लेस्टोन (claystone), मडस्टोन (mudstone), सिल्टस्टोन (siltstone) आदिमा पाइन्छन् । हुन त हालसालै यस पङ्क्तिकारका विद्यावारिधि शोध सहनिर्देशक अष्ट्रियास्थित भिएना विश्वविद्यालयका प्राध्यापक डा. राइनहार्ड जेटरले यूरोपको आइसल्यान्ड र क्यानाडाको ब्रिटिस कोलम्बियास्थित प्रिन्सेटोन चर्टमा (Princeton Chert) इयोसिन (Eocene) समयका परागकण रहेको तथ्य प्रकासमा ल्याएका छन् । परागकणकै आधारमा उनले त्यससमयको प्रागजैविकभूगोलको (palaeobiogeography) चर्चासमेत गरेका छन् (Grimsson et al. 2008) । यसले पराग अध्ययन गर्ने वैज्ञानिकहरूको सानो संसारमा तरङ्ग उत्पन्न गरेको छ । पुरापराग अध्ययनका लागि स्याम्पल (नमूना) सङ्कलन गर्दा चट्टानको प्रकार र रङ्गले विशेष महत्व राख्दछ । जलवायु परिवर्तनको अध्ययनका लागि साधारणतया कार्बनिक पदार्थयुक्त कालो, खरानी वा हल्का खैरो रङ्गका चट्टानका प्रत्येक तह (bed) बाट प्रत्येक १० देखि ३० सेन्टिमिटरको अन्तरालमा स्याम्पल सङ्कलन गर्ने गरिन्छ । खस्रो (coarse grained), ज्यादै रातो, गाढा खैरो वा हरियो रङ्गका चट्टानहरूमा अक्सिडेसनका कारणले परागका जीवावशेष नष्ट भइसकेका हुन्छन् । परागकण अत्यन्त सूक्ष्म आकारका हुने हुनाले स्याम्पलमा पराग रहेको अनुमानका आधारमा नै त्यसलाई सङ्कलन गरिन्छ । स्याम्पलहरूलाई वायुमण्डलमा तैरिरहेका वर्तमान वनस्पतिका परागकणहरूले प्रदूषित गर्न सक्ने हुँदा प्रयोगशालासम्म सुरक्षित रूपमा पुऱ्याउनु पर्ने हुन्छ ।

४.ख. पृथकीकरण

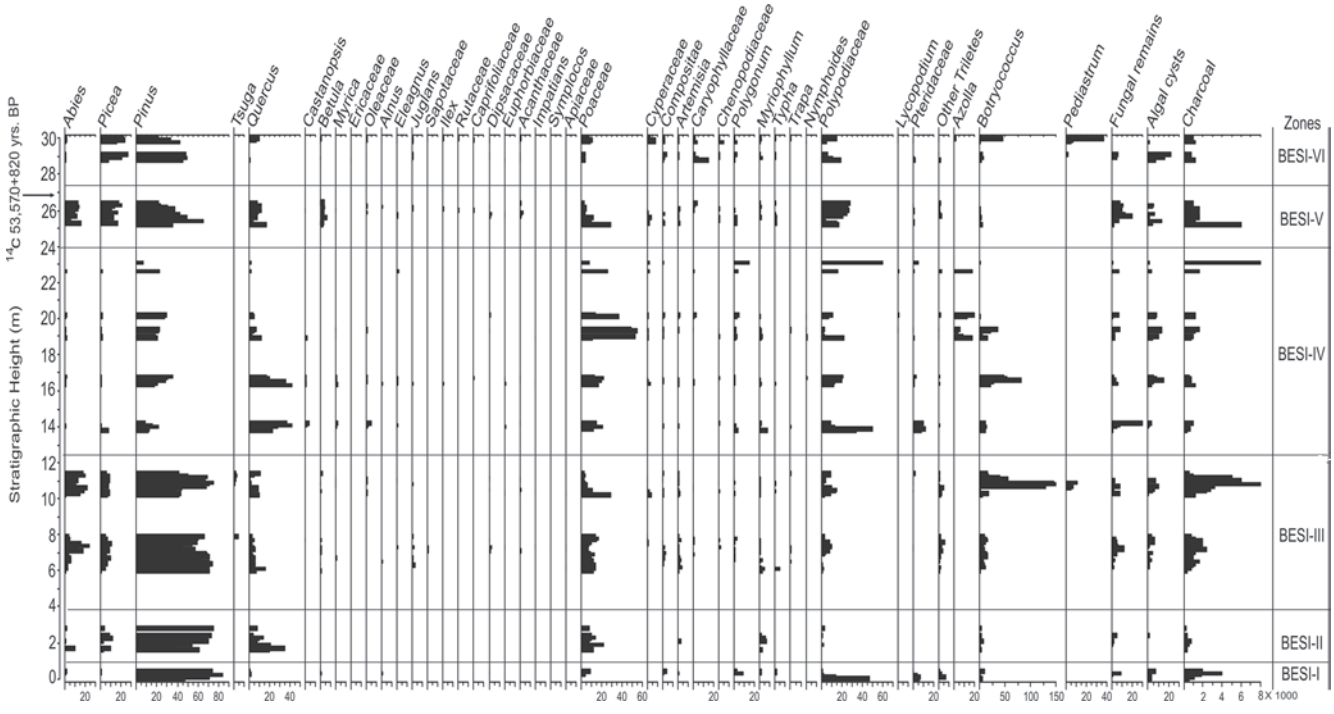
चट्टानबाट पुरापराग पृथक गर्ने कार्य अत्यन्त जटिल छ । यसका लागि सर्वप्रथम चट्टानलाई धुलो पार्ने र हाइड्रोक्लोरिक एसिड (HCl) एवम् हाइड्रोफ्लोरिक एसिडमा (HF) पकाउनु पर्ने हुन्छ । हाइड्रोक्लोरिक एसिडले कार्बोनेटसँग प्रतिक्रिया गर्छ र स्याम्पललाई यसबाट मुक्त गर्छ । त्यस्तै हाइड्रोफ्लुओरिक एसिडले विभिन्न सिलिकेटहरूसँग प्रतिक्रिया गर्छ र सिलिकेटका अवयवहरूलाई घटाउने कार्य गर्दछ । त्यसपछि स्याम्पललाई एसिटोलाइसिस सोलुसन (९:१ अनुपातका मिश्रण गरिएको एसेटिक एनहाइड्राइड र सल्फ्युरिक एसिड) सँग प्रतिक्रिया गराइन्छ । यसले परागलाई सेलुलोज र ह्युमिक एसिडबाट मुक्त गर्छ । अन्त्यमा २.० घनत्व भएको ग्रहौँ तरल अर्थात् हेभि सोलुसन (Zinc Chloride) का माध्यमले स्याम्पलमा बाँकी रहेको अकार्बनिक अवयवबाट कार्बनिक अवयवलाई पृथक गर्ने कार्य गरिन्छ । यसपछि बाँकी रहेको कार्बनिक अवयवलाई ग्लीसरिन जेलीमा राखिन्छ र माइक्रोस्कोपमा अवलोकन गरिन्छ (Zetter 1989, Ferguson et al. 2007) ।

४.ग. पहिचान र अभिलेख

परागकणको पहिचानका लागि वानस्पतिक ज्ञानको आवश्यकता पर्दछ । सर्वप्रथम परागकण कुनकुन वनस्पतिका हुन पहिचान गर्नु नै पराग अध्ययनको पहिलो पाइलो हो । त्यसका लागि परागकण मात्र अध्ययन गरेर मात्र पुग्दैन । उपलब्ध परागकणहरू कस्तो वृक्ष (tree), पोथ्रा (shrub) अथवा घाँस (grass) वर्गका हुन र तिनले कस्तो पारिस्थितिकी मन पराउँछन् त्यस कुराले विशिष्ट अर्थ राख्दछ । परागका आधारमा तत्कालीन समयको वनजङ्गलका साथै वनस्पतिको विन्यास ज्ञान हुन्छ अनि प्रागसमयको पारिस्थितिकी पुनर्निर्माण (palaeoclimate reconstruction) गर्न सकिन्छ ।

परागकण प्राय गोलाकार वा वर्तुल हुन्छन् र तिनीहरूलाई तिनीहरूको आकार, बाहिरी सतह (exine) को मोटाई र त्यसमा रहेका विभिन्न बुट्टाहरू (ornamentation) का आधारमा पहिचान गर्न सकिन्छ । परागकणमा विभिन्न प्रकारमा छिद्रहरू (प्वाल) रहेका हुन्छन् । ती छिद्रहरूलाई एपरचर (aperture) भनिन्छ । परागसेचनका क्रममा परागबाट परागनली निस्कनका लागि परागमा यस्ता छिद्रहरूको निर्माण भएको हुन्छ । छिद्रहरू कुनै गोलाकार (pore) र कुनै सरलाकार (colpus) हुन्छन् । कुनैकुनै वनस्पतिमा गोलाकार र सरलाकार छिद्रहरूको संयोग भएर भिन्नै छिद्रको निर्माण भएको हुन्छ । यस्ता छिद्रहरूलाई कोल्पोरेट एपरचर (colporate aperture) भनिन्छ । परागकणको पहिचानमा छिद्रहरूको प्रकार, सङ्ख्या र परागको सतहमा स्थित बुट्टाहरूको ठूलो महत्व रहेको हुन्छ । परागकण ध्रुवीय र मध्यरेखीय दिशाबाट अवलोकन गर्दा फरकफरक देखिने हुँदा सही पहिचानका लागि त्यसलाई दुवै कोणबाट अवलोकन गर्नु पर्दछ । परागकण कुन जाति (genus) वा प्रजाति (species) को हो यकिन भइसकेपछि तिनीहरूको सङ्ख्या गणना गरिन्छ । प्रत्येक स्याम्पलमा रहेका कम्तीमा पाँचसय परागकणहरूको सङ्ख्या गणना गरिसकेपछि कुल सङ्ख्याका आधारमा प्रत्येक जाति वा प्रजातिको प्रतिशत छुट्याउने काम गरिन्छ । यसपछि उक्त तथ्याङ्कको आधारमा एउटा ग्राफ बनाइन्छ जसलाई परागचित्र (pollen diagram) भनिन्छ । यही परागचित्रमा जलवायु परिवर्तनका सङ्केतहरू अवलोकन गरिन्छ । तलको परागचित्रमा काठमाडौँ उपत्यकाको गोकर्ण फर्मेसन अन्तर्गत बेसीगाउँ क्षेत्रमा भेटिएका पुरापरागका आधारमा प्रागवातावरण निर्माण गरिएको देखाइएको छ (चित्र नं. ३) । यस चित्रमा BESI-I देखि BESI-III सम्म शीतोष्ण क्षेत्रमा पाइने वनस्पतिहरूको प्राधान्यता देखिन्छ । BESI-IV मा उष्ण जलवायुको आगमन र BESI-V र BESI-VI मा पुनः शीतोष्ण जलवायु पुनरागमन भएको देखिन्छ । काठमाडौँको गोकर्ण, ठिमी र पाटन फर्मेसनमा पाइने केही पुरापरागहरूको फोटोहरू चित्र नं. ४ र ५ मा प्रस्तुत गरिएको छ ।

परागका आधारमा जलवायु परिवर्तनका आधारहरू पहिल्याउन त्यति सजिलो छैन । वनस्पतिका विशेष जाति तथा प्रजातिहरूका आआफ्नै पारिस्थितिक आवश्यकताहरू (ecological needs) हुन्छन् । जलवायु परिवर्तन हुँदै जाँदा वनस्पतिले आफूलाई अनुकुल पारिस्थितिकीतर्फ डोऱ्याउन थाल्छन् । यस्तो प्रकृयालाई वनस्पतिको बसाइसराइ (plant migration) पनि भनिन्छ । आफूलाई अनुकुल पारिस्थितिकीतर्फ डोऱ्याउन नसक्ने वनस्पति लोप हुने प्रबल सम्भावना रहन्छ । जब जलवायु उष्णतातिर जान्छ त्यसबेला उष्ण जलवायुमा बाँच्न सक्ने वनस्पतिको प्राधान्यता रहन्छ । फलस्वरूप तत्कालीन समयमा उष्णता मन पराउने वनस्पतिका परागहरू वायुमण्डलमा व्याप्त हुन्छन् र त्यस्ता परागकणहरू



चित्र नं. ३: काठमाडौँ उपत्यकाको गोकर्ण फर्मेसनअन्तर्गत बेसीगाउँ क्षेत्रमा भेटिएका पुरापरागका आधारमा निर्माण गरिएको परागचित्र (pollen diagram)।

नै नदी, ताल, समुद्रमा थेग्रिन पुग्छन्। जब जलवायु शीतलतातिर जान्छ त्यसबेला शीतोष्ण वा समशीतोष्ण जलवायुमा बाँच्न सक्ने वनस्पतिको प्राधान्यता रहन्छ। फलस्वरूप तत्कालीन समयमा चिसो मनपराउने वनस्पतिका परागहरू वायुमण्डलमा व्याप्त हुन्छन् र त्यस्ता परागकणहरू नै नदी, ताल, समुद्रमा थेग्रिन पुग्छन्। कालान्तरका जलवायुविद् (climatologist) ले चट्टानका पत्रपत्रबाट त्यस्ता परागहरूको अध्ययन गर्दछ र प्रागवातावरणको पुनर्निर्माण (palaeoclimatic reconstruction) गर्दछ। त्यसैका आधारका पृथ्वीको विगतको जलवायु यात्राका बारेमा जानकारी प्राप्त हुन्छ र भविष्यको जलवायु परिवर्तनको पूर्वानुमान गर्ने सन्दर्भसमेत प्राप्त हुन्छ।

५. निष्कर्ष

परागविद्या जलवायु परिवर्तनको विधिवत् अध्ययनका लागि एउटा यथार्थपरक माध्यम हो। विश्वभरि जलवायु परिवर्तन अध्ययनअनुसन्धानका क्रममा व्यापक रूपमा पुरापरागको अध्ययन भइरहेको छ। युरोप, अमेरिका र क्यानाडा लगायतका मुलुकहरूले क्वाटर्नरी समय (Quaternary Epoch) का चट्टानहरूमा रहेका पुरापराग अध्ययन गरेर विगत केही सय वा हजार वर्षसम्मको जलवायु परिवर्तनको इतिहास अभिलेख गरिसकेका छन्। साधनस्रोत र ज्ञानको कमीले हामीले यस क्षेत्रमा उल्लेख्य तथ्याङ्कहरू उत्पादन गर्न सकेका छैनौ। जलवायु परिवर्तनका बारेमा विगतको सही ज्ञान प्राप्त नभएसम्म वर्तमान र भविष्यका बारेमा अनुमान गर्न कठीन हुन्छ। हामीले हिमालय पर्वत श्रृङ्खलाको निर्माण भएपछि स्थापित भएको मनसुन जलवायुको विकास (evolution of monsoonal climate system) का बारेमा अध्ययन गर्न बाँकी नै छ। यसकालागि परागकणको अध्ययन एउटा सशक्त माध्यम हुन सक्दछ।

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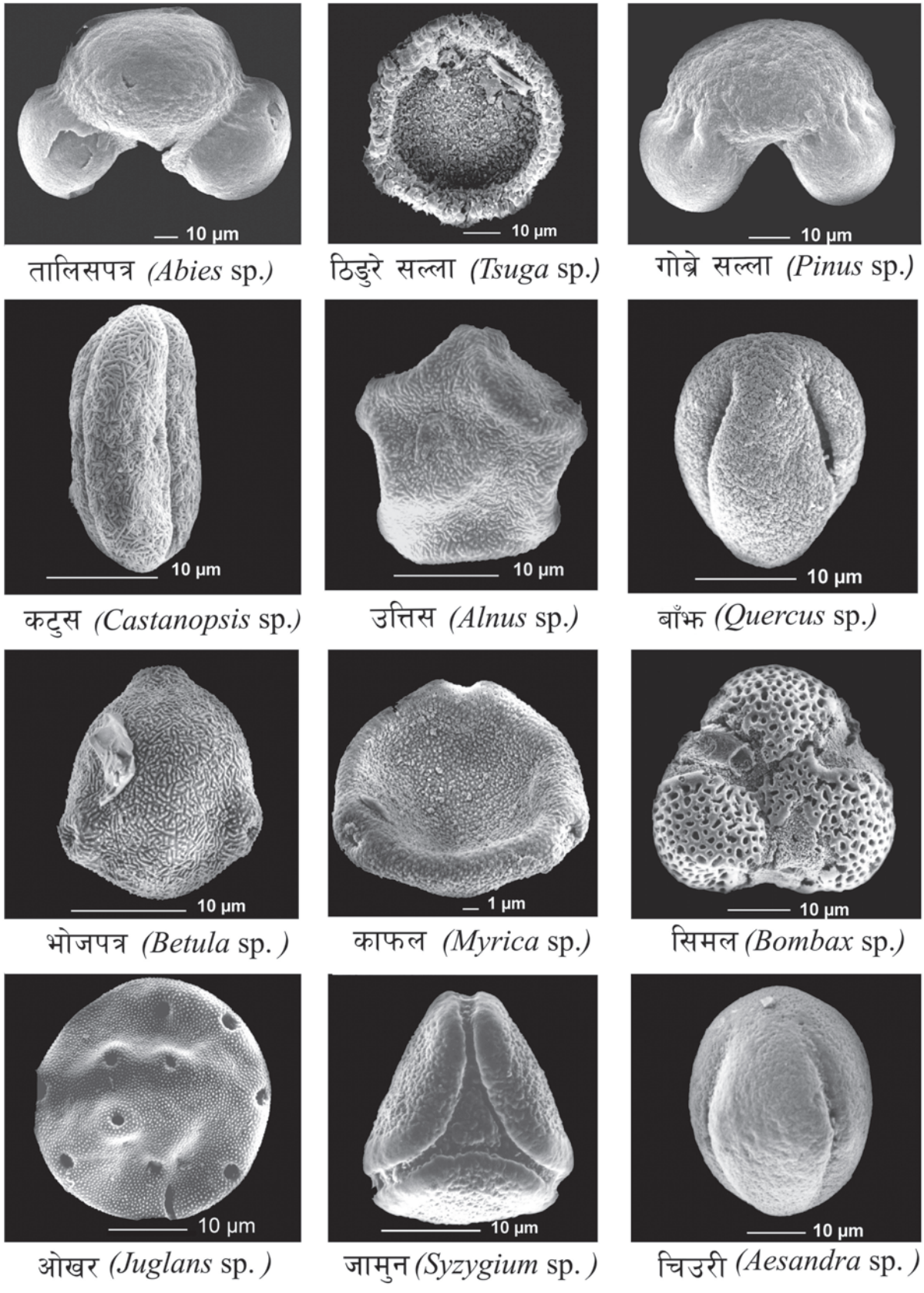
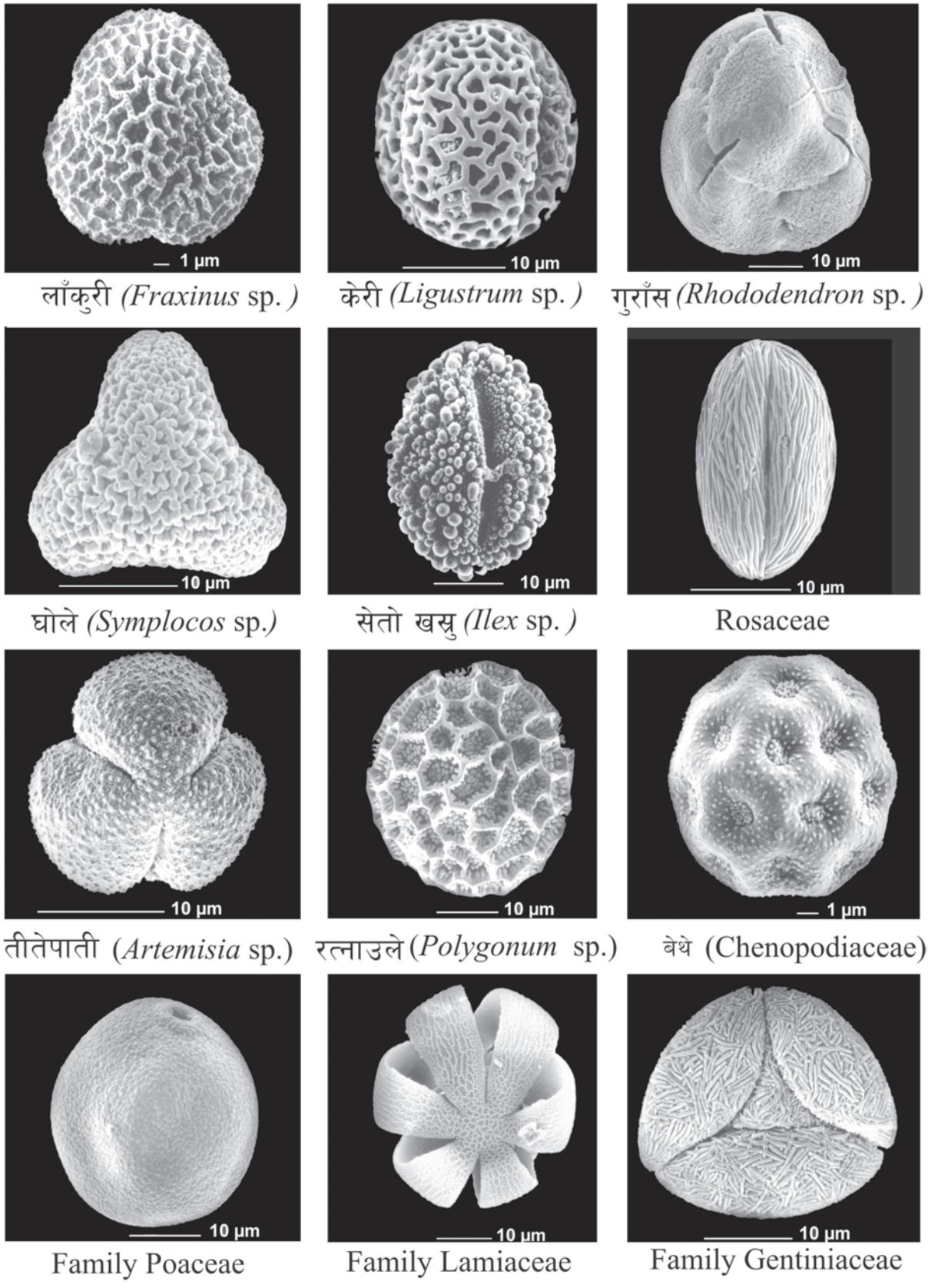


चित्र नं. ४: काठमाडौँ उपत्यकामा पाइने केही महत्वपूर्ण ठूला बृक्षका पुरापरागहरू



चित्र नं. ५: काठमाडौँ उपत्यकामा पाइने केही महत्वपूर्ण साना बृक्ष, पोथ्रा र घाँसहरूका पुरापरागहरू

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AWARD OF THE HONORARY FELLOWSHIP OF THE NEPAL GEOLOGICAL SOCIETY

The Nepal Geological Society had conferred upon the Honorary Fellowship of the Nepal Geological Society to Prof. Dr. Kazunori Arita, University of Hokkaido, Japan and Mr. Jhumar Mal Tater, Former Duputy Director General, Department of Mines and Geology, Government of Nepal on the occasion of Sixth Nepal Geological Congress of the Nepal Geological Society on November 2010 in recognition of their contribution towards scientific research and the development of the Himalaya.

PROF. DR. KAZUNORI ARITA, JAPAN

Prof. Dr. Kazunori Arita was born in 1941 in Sapporo, Japan. He received his B.Sc., M.Sc. and Doctor of Philosophy (Ph. D.) degrees in Geology in 1965, 1969 and 1975, respectively from Hokkaido University, Japan. After completing his education, he joined the Department of Geology and Mineralogy of Hokkaido University as a Research Associate in 1975. He was promoted to the post of Professor in 2003 in the same university, and continued research and education until retirement in 2005. Currently, he is affiliated with the Hokkaido University Museum, where he continues his research activities.

Prof. Dr. Arita loves mountains. For this reason, since the very beginning of his academic and research career, he was actively involved in the geological studies of the Himalayan mountain range, particularly in Nepal and in Japan. He has spent his entire career of nearly four decades working in the Himalaya and Japan to understand the way the mountains form, particularly to understand their metamorphic and tectonic histories. His first trip to Nepal was in 1968, as a member of the Hokkaido University Nepal Himalaya Scientific Research Expedition. He continued visiting Nepal in connection with field surveys in 1980, 1982, 1984, 1988 and 1989 as members of scientific research projects. He was also the leader of a large research project on the mountain uplift and climate changes in Nepal Himalaya run during 1999-2001 and financed by the Ministry of Education, Government of Japan.

He received two Nepalese students in Hokkaido University as Monbusho scholarship holders and supervised one of them for Ph. D. degree. He continues scientific collaborations with the Tribhuvan University and Department of Mines and Geology in Nepal. He is one of the active Life Members of Nepal Geological Society. He was also the editor of the Journal of Nepal Geological Society from 2001 to 2004. He has helped to promote the advancement of geoscientific research in Nepal Himalaya through various seminars and symposia in Japan, Nepal and elsewhere. One of such big events led by him was the organization of the 19th International Himalaya-Karakoram-Tibet Workshop held in Niseko, Hokkaido in 2004 attended by some 140 international participants. He is promoting Japan-Nepal friendship as an active member of the Japan-Nepal Society, Hokkaido Branch, in which he has held executive positions.

Prof. Dr. Kazunori Arita

Prof. Dr. Arita is the editor and co-author of one of the very few books that exists on the geology of Nepal called 'Geology of the Nepal Himalayas', which was published in 1973 in Japan. He has also written a popular book called "Himalayas: why are they so high?" published in Japanese language in 1988. Prof. Arita is a well known Himalayan geoscientist and has authored and co-authored about 50 scientific research papers/articles and 6 books related to the Himalayas, mainly on Nepal. Some of his publications in the Journal of Nepal Geological Society have been widely referred in the geological literature. He is a Life Member of Nepal Geological Society and also the member of many other geoscientific societies including the Geological Society of America, American Geophysical Union, etc.

He was honored by the **AWARD OF THE HONORARY FELLOWSHIP** of the Nepal Geological Society in 2010 AD.

MR. JHUMAR MAL TATER, NEPAL

Mr. Jhumar Mal Tater was born in 1938 at Hanumannagar, Nepal. He completed B. Sc. (Hons.) Degree with First Class from Bihar University, India and received M. Sc. Degree in Applied Geology from the same university standing First Class First for which he was awarded Gold Medal. Later, he did A.I.S.M. in Applied Geology from Indian School of Mines, Dhanbad, India and was awarded Hayden medal for securing First Class First. After joining the Nepal Government service, he earned second Masters from University of Alberta, Canada. His academic excellence was always outstanding.

Mr. Tater joined Nepal Bureau of Mines in 1959 as a geologist. He was mainly involved in geological mapping programs. After the establishment of the Department of Geological Survey, in a capacity of Senior Geologist, Mr. Tater formulated intensive geological mapping programs in the eastern parts of Nepal and implemented them over the years under his guidance and supervision. In 1970, Mr. Tater got promotion to Superintending Geologist (Class I). In this capacity, he played a pivotal role in opening up opportunities for new geologists by creating significant number of posts in the Geological Survey Department. By engaging teams of geologists in the field, he was able to help produce geological maps covering a large portion of the country. Under his guidance, first Geological Map of Nepal (Scale1:500,000) was published followed by publications of Regional Geological Maps of 5 Development Regions. He along with then Director General Late Mr. R. H. Khan, published several short papers and booklets including age dating results of Nepalese rocks. Mr. Tater took a lead role in convincing the policy makers in the government about importance of geological maps in infrastructural planning and natural resource management.

From September 1976 to July 1982, Mr. Tater became the Deputy Director General of Department of Mines and Geology, which was formed as a result of amalgamation of two Departments (Nepal Bureau of Mines and Nepal Geological Survey). From July 1982 to November 1990,

Mr. Jhumar Mal Tater

he was In-charge of Petroleum Exploration Project, and in November 1990 he became Project Chief of Petroleum Exploration Promotion Project (PEPP) and continued till his retirement in November 1992. During his tenure with PEPP, he played a key role in drafting Petroleum Laws, generating data packages for petroleum exploration with supports of World Bank, Canadian Government and French Government. Through his promotional campaigns and able leadership, International Oil Companies like Shell were attracted to the acreages of Nepal for petroleum exploration. His contribution to petroleum exploration promotion in Nepal has been extremely praiseworthy.

He was honored by the **AWARD OF THE HONORARY FELLOWSHIP** of the Nepal Geological Society in 2010 AD.

CONGRATULATIONS

The Nepal Geological Society extends the heartiest congratulation to Dr. Dinesh Chandra Devkota (LM 558) for his appointment by the Government of Nepal as **Vice-Chairman** of the National Planning Commission, Government of Nepal.

Dr. Dinesh Chandra Devkota

Dr. Som Nath Sapkota

The Nepal Geological Society expresses the heartiest congratulation to Dr. Som Nath Sapkota (LM 331) for obtaining a **Ph. D. degree** from the Institut de Physique du Globe de Paris (IPGP), Paris, France in 2011. The topic of his dissertation was **Surface Rupture of 1934 Bihar-Nepal Earthquake: Implications for Seismic Hazard in Nepal Himalaya**.

The Nepal Geological Society expresses the heartiest congratulation to Dr. Moti Rijal (LM 425) for obtaining a **Ph. D. degree** from the Centre for Applied Geosciences, University of Tuebingen, Germany, in 2010. The topic of his dissertation was "**Hydrocarbon contamination induced changes of magnetic properties in soil and sediment**."

Dr. Moti Rijal

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GUIDEBOOK for HIMALAYAN TREKKERS

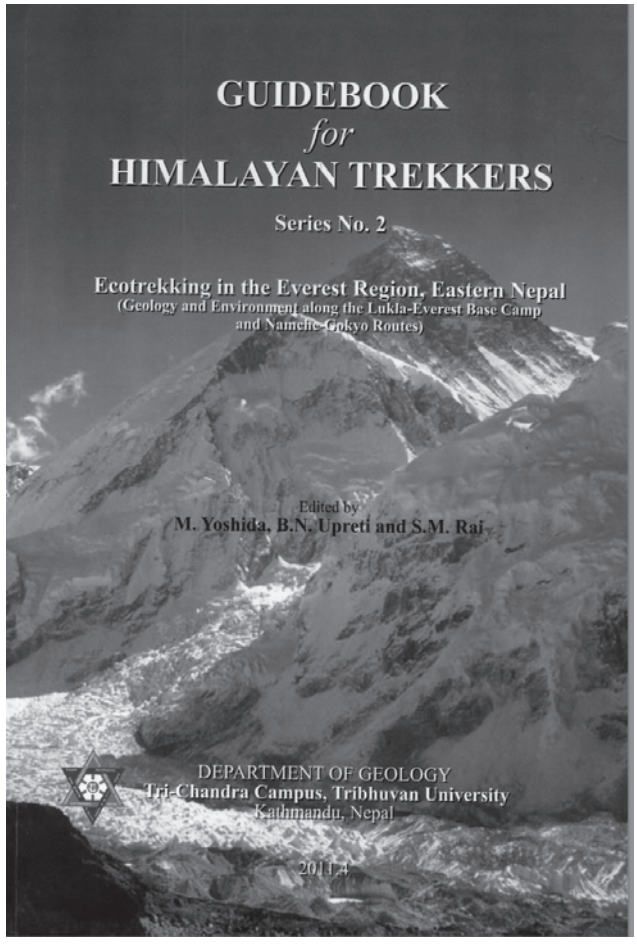
Series No. 2 Ecotrekking in the Everest Region, Eastern Nepal
(Geology and Environment along the Lukla-Everest Base Camp and Namche-Gokyo Routes)

Edited by M. Yoshida, B. N. Upreti and S. M. Rai

The Himalaya is the highest, youngest and most active mountains on the Earth. The mountain exhibits remarkable zonal arrangement of altitude, climate, topography, and geology, representing the typical natural constitution of a mountain range. Thus, it is an ideal natural laboratory that provides a unique opportunity to study the nature of our Mother Earth. A handy and beautiful Himalayan guidebook was published from the Department of Geology, Tri-Chandra Campus, Tribhuvan University of Nepal. The guidebook is formed through extensive literature studies of the Everest Region and whole Himalaya, along with several expeditions of field survey in the region by Department staffs that amounted about 200 days' work. Contributors included 10 staffs of the Department, including emeritus Prof. M. Yoshida. The book forms the special publication No. 3 of the Department.

The Bhotekoshi River cuts through the Khumbu Himalayan mountains in the north-south direction. It originates from the world-highest Mt. Everest (Sagarmatha). The guidebook covers about a 100 km section from Mt. Everest in the north to Khari Khola/Jubin in the south. Geologically, the section covers the Lesser Himalayan Zone in the south, the Higher Himalayan Zone in the middle, and the Tethys Zone in the north, among which the middle zone occupies the widest section. As one treks from south to north, an amazing change of beautiful mountain scenery, as well as geology, topography, climate and vegetation can be clearly noticed. The trekking along the valley provides an exciting opportunity to experience the essence of the natural beauty, fascinating geology and geography. The cover of the guidebook shows beautiful geology and topography of Mt. Everest and the back cover shows the model trekking route of 7 days from Lukla to the Everest Base Camp. This route map also appears in the beginning of the book associated with the model itinerary, that will encourage people to go the trekking on this route.

All the guidebook style, composition, quality, etc followed that of the guidebook series No 1, Geology and Natural Hazards along the Kaligandaki Valley, Central Nepal. The guidebook is composed of three parts, the introductory two chapters, the field guide chapters, and appendixes. In addition, a complete reference list is also attached after chapter 3. The first 40 pages of the book including the introductory chapters deals with the general introduction of nature, particularly of earth science and environment of the whole Himalayan range and those of the Everest region. Here several important maps along with precise reference lists are given with detailed explanations, so that people can get a recent understanding of the Himalayan geology and environment.



The following major part, 105 pages of the book composed of field observations gives general physiographic and geologic characters of all six courses in the region, followed by detailed explanation of 92 observation stops with 200 photos and figures including 12 maps of about 1/ 50,000 scale. Beautiful field photos with detailed explanations facilitate readers to easy understanding.

The last appendixes part, includes glossary, geological time scale and index. The glossary is very effective for the trekkers without special knowledge on geoscience to be able to read the guidebook with better understanding. As a whole the guidebook is well written with a good scientific value, and is also meticulously organized for easy reading. It will

surely be a valuable guidebook for trekkers as well as geologists and engineers who are interested in learning the nature, specifically geology, geomorphology, natural hazards and vegetation in the Himalaya and the Everest region. The Series No. 3 of the guidebook is planned for the Langtang Valley route that is also very much expected. Forfurther information, please visit the following websites of the Department of Geology: http://www.geology.edu.np and of the Gondwana Institute for Geology and Environment: http;//geocities.jp/gondwanainst/.

The book is sold in bookshops in Kathmandu by 950 rupees. For international order, it costs 40 US dollars including postage and handling charges, and should be ordered to either one of the following addresses: Prof. B.N. Upreti: bnupreti@wlink.com.np; Dr. T. N. Bhattarai: tnbhattarai@wlink.com.np, Secretarial, Department of Geology, Tri-Chandra Campus, Tribhuvan University: info@geology.edu.np; and Prof. M. Yoshida: gondwana@oregano.ocn.ne.jp

ANNOUNCEMENT

27TH HIMALAYA-KARAKORUM-TIBET (HKT) WORKSHOP

29-30 November, 2012
Kathmandu, Nepal

Nepal Geological Society is going to organize the International Workshop of 27th Himalaya-Karakorum-Tibet (HKT) on 29-30 November, 2012 in Kathmandu, Nepal. All the members of NGS and other interested persons/institutions/NGOs/INGOs, etc. are kindly requested to visit the website of NGS: www.ngs.org.np

For details, please contact:
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Manuscript

Send a disk file (preferably in MS Word) and three paper copies of the manuscript, printed on one side of the paper, all copy (including references, figure captions, and tables) double-spaced and in 12-point type with a minimum 2.5 cm margin on all four sides (for reviewer and editor marking and comment). Include three neat, legible copies of all figures. Single-spaced manuscripts or those with inadequate margins or unreadable text, illustrations, or tables will be returned to the author unreviewed.

The manuscripts and all the correspondences regarding the Journal of Nepal Geological Society should be addressed to the Chief Editor, Nepal Geological Society, PO Box 231, Kathmandu, Nepal (Email: publication@ngs.org.np).

The acceptance or rejection of a manuscript is based on appraisal of the paper by two or more reviewers designated by the Editorial Board. Critical review determines the suitability of the paper, originality, and the adequacy and conciseness of the presentation. The manuscripts are returned to the author with suggestions for revision, condensation, or final polish.

After the manuscript has been accepted, the editors will ask the author to submit it in an electronic format for final processing. Manuscripts are copy edited. Final changes must be made at this time, because no galley proofs are sent to authors.

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Authors are responsible for providing manuscripts in which approved geological and other scientific terminology is used correctly and which have no grammar or spelling errors. Authors must check their manuscripts for accuracy and consistency in use of capitalisation, spelling, abbreviations, and dates.

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Auden, J. B., 1934, Traverses in the Himalaya. Rec. Geol. Surv. India, v. 69(2), pp. 123–167.

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Tokuoka, T. and Yoshida, M., 1984, Some characteristics of Siwalik (Churia) Group in Chitwan Dun, Central Nepal. Jour. Nepal Geol. Soc., v. 4, (Sp. Issue), pp. 26–55.

Reprints

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